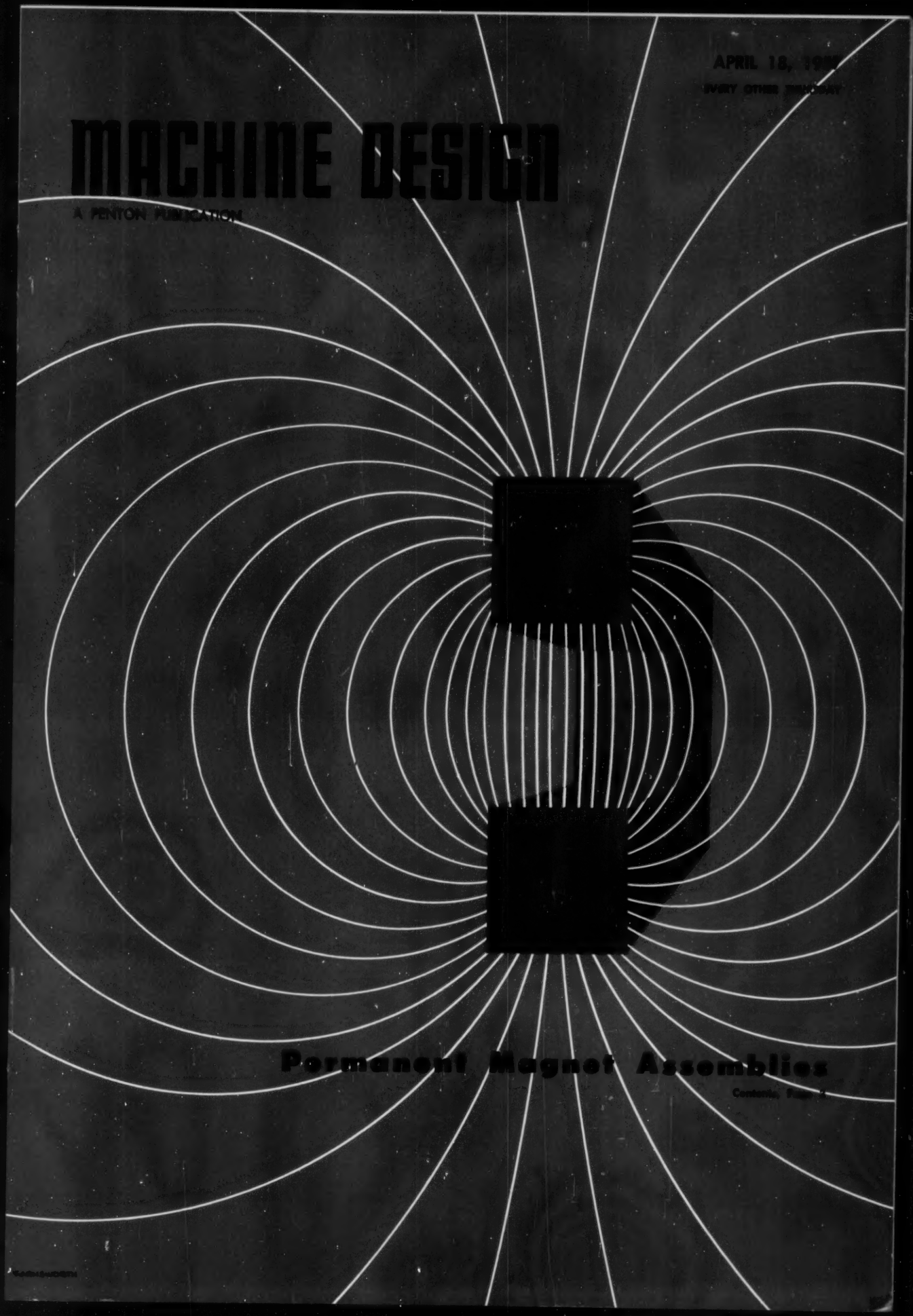
APRIL 18, 1957
EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION



Permanent Magnet Assemblies

Contents, Page 3

Install it... then Forget it!

The

NORMA-HOFFMANN

"CARTRIDGE"

BEARING

•

Needs No Attention

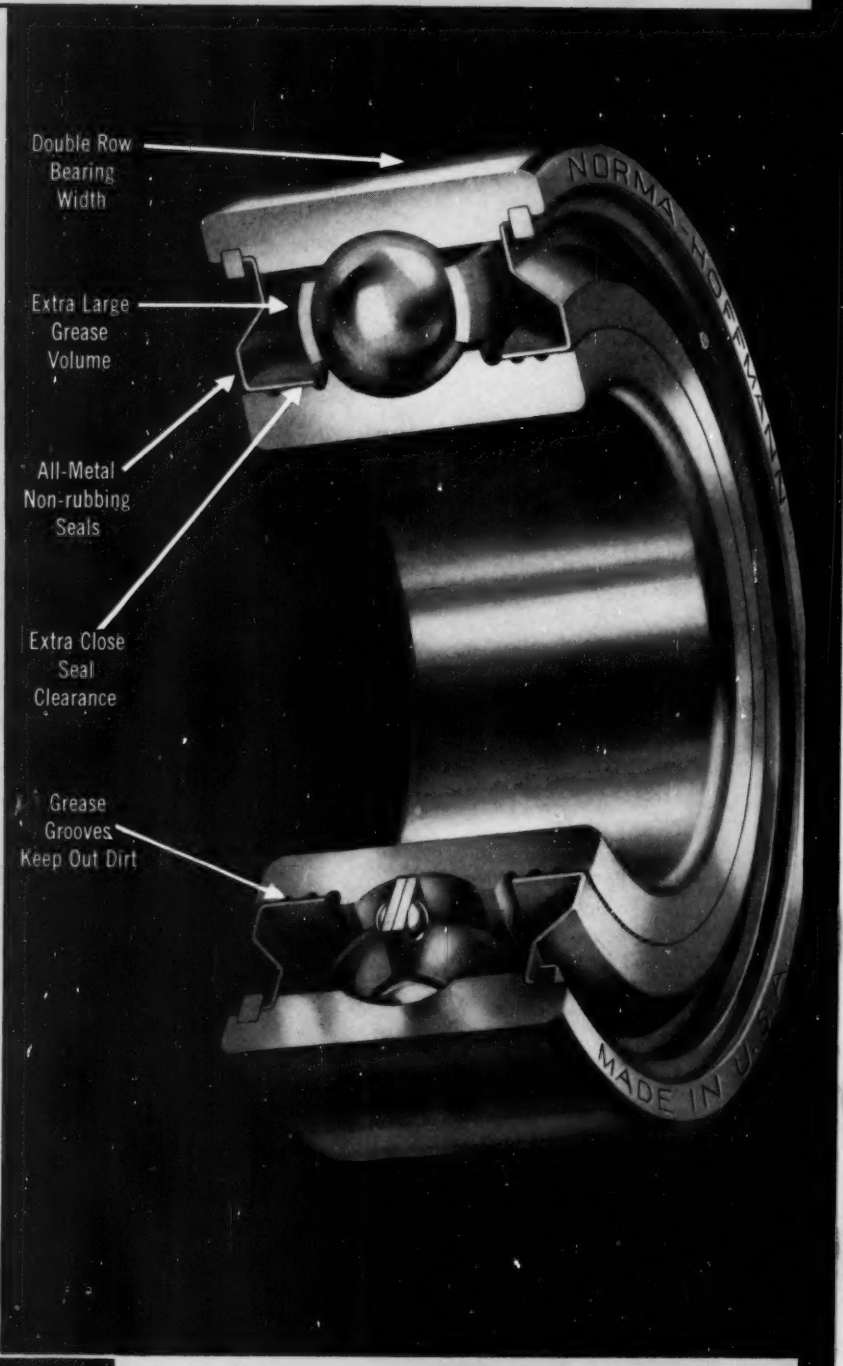
"Cartridge" ball bearings installed more than 15 years are still running without relubrication.

Here's Why:

"Cartridge" double row width bearings are complete units — ready for installation.

"Cartridge" bearings are adequately lubricated — with correct amount and the right kind of grease.

"Cartridge" bearings are fully protected — with highly efficient all-metal, non-rubbing lifetime seals.



NORMA-HOFFMANN *Precision* **BEARINGS**

BALL • ROLLER • THRUST

NORMA-HOFFMANN BEARINGS CORPORATION

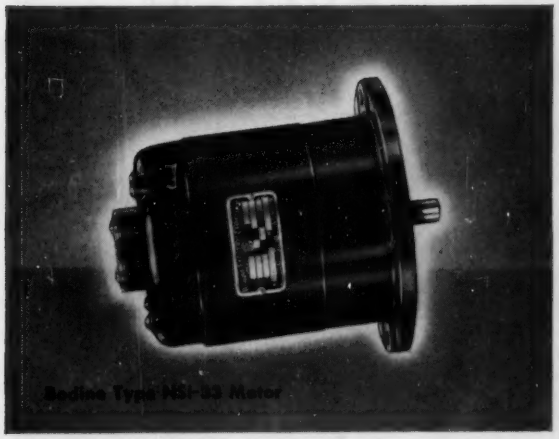
STAMFORD, CONNECTICUT

FOUNDED IN 1911

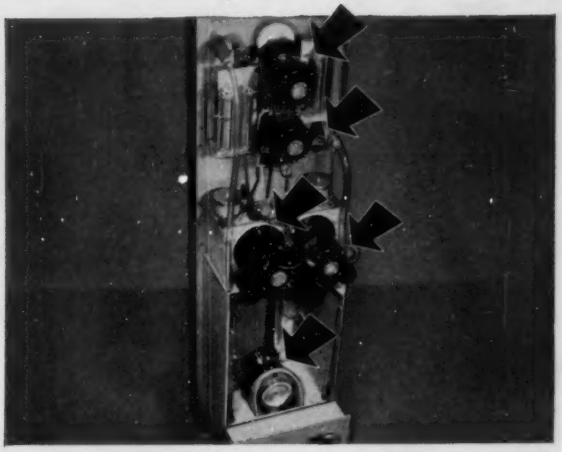
FIELD OFFICES: Atlanta, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Kansas City, Los Angeles, San Francisco, Seattle

Circle 401 on page 19

Burroughs Datatron uses BODINE MOTORS because..."THEY REQUIRE MINIMUM MAINTENANCE, HAVE LONG LIFE"



This is one of the five Bodine Type N Motors used in Burroughs Datatron magnetic tape transport units which provide additional information storage for "electronic brains." Burroughs has found these motors to "have long life, require only minimum maintenance and be dependable." This and similar findings by other leading manufacturers are mainly the result of our close tolerance machining and attention to minor details often overlooked.



Here's an inside view of the Burroughs Datafile showing the five Bodine Motors. The top two 1/15 HP, 1725 rpm motors are shunt wound and drive the reels, while the middle two are 1/20 HP, 1800 rpm hysteresis synchronous units and drive the capstan. The lower split-phase motor is also 1/20 HP and powers the blower. The Bodine Motors are all part of the Datatron's vacuum column drive which gives stable strain-free tape movement with 6 ms start/stop time.

At the left are 3 Datatron magnetic tape transport units which are used to augment the computer's memory. Ten of these units can be used in a system, increasing the "electronic brain's" memory by more than 40 million digits. These magnetic tape units search, read and write data on their tape at 60 in/sec in either direction.

Mr. Duncan MacDonald is chief electromechanical engineer of ElectroData Division, Burroughs Corporation, Pasadena, California, manufacturers of ElectroData systems. Mr. Duncan tells how and why his organization selected Bodine Motors . . .

"The selection of Bodine Motors was no casual decision arbitrarily made. Dependability and reproducible performance were paramount requirements of the tape system. Naturally, the components used had to measure up to the design. Bodine Motors, we felt, met the requirements for dependability, minimum maintenance, and long life. The system's proven reliability in the field indicates our choice was the right one."

Be sure *your* motor is as good as your product. For information contact Bodine Electric Company, 2258 West Ohio St., Chicago 12, Ill.

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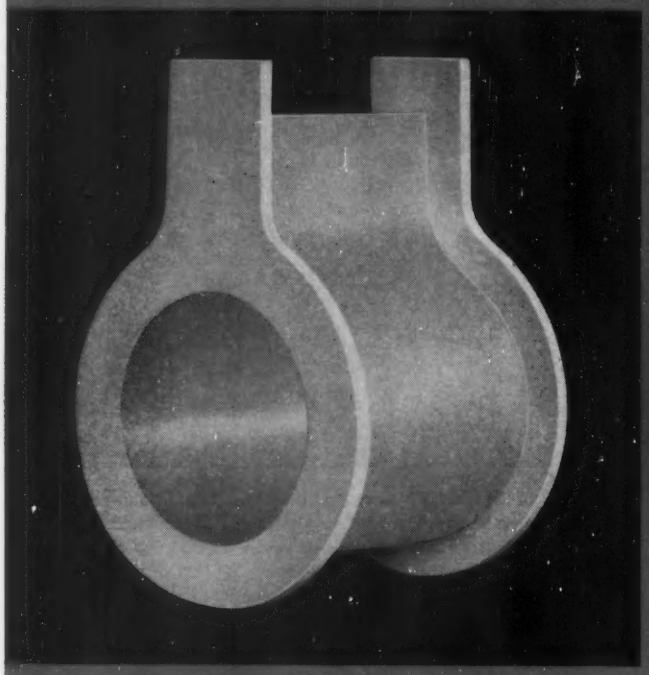
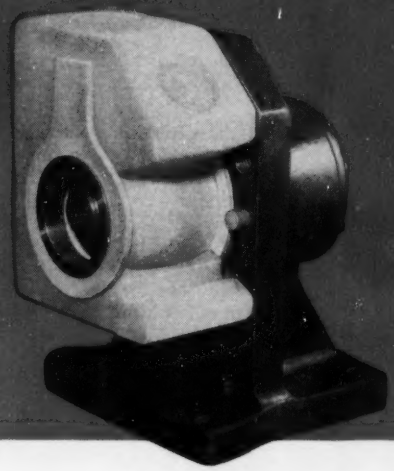
Circle 404 on page 19

PUMPS FUMING NITRIC ACID

14.7 MILLION CYCLES





...AND THE HEART OF THIS VANTON PUMP IS C/R SIRVENE

Vanton Pump engineers knew what they wanted—a flexible liner for their unique Flex-I-Liner pump that would permit the handling of red and white fuming nitric acid, hydrogen peroxide and other strong oxidizing agents. In addition, high flexibility had to be combined with positive sealing efficiency to protect the rotor, shaft and bearing from contact with the corrosive chemicals. For almost six years Vanton engineers tested various liners and found none that could withstand these unusually severe specifications. Then they turned the problem over to C/R Sirvene engineers. They got the liner they wanted in a matter of weeks. C/R's Sirvene liner, based on the Kel-F elastomer, meets every specification and has been performing dependably for as long as 14.7 million cycles.

If you have a sealing problem—equally critical or simple—C/R Sirvene engineers can help you. They're recognized leaders in the compounding and molding of elastomers for fluid sealing and related applications. They have the research and facilities to solve your problem quickly and economically. Write them direct—or send for the informative new booklet, "Sirvene."

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THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

April 18, 1957
Volume 29—No. 8

REGULAR DEPARTMENTS

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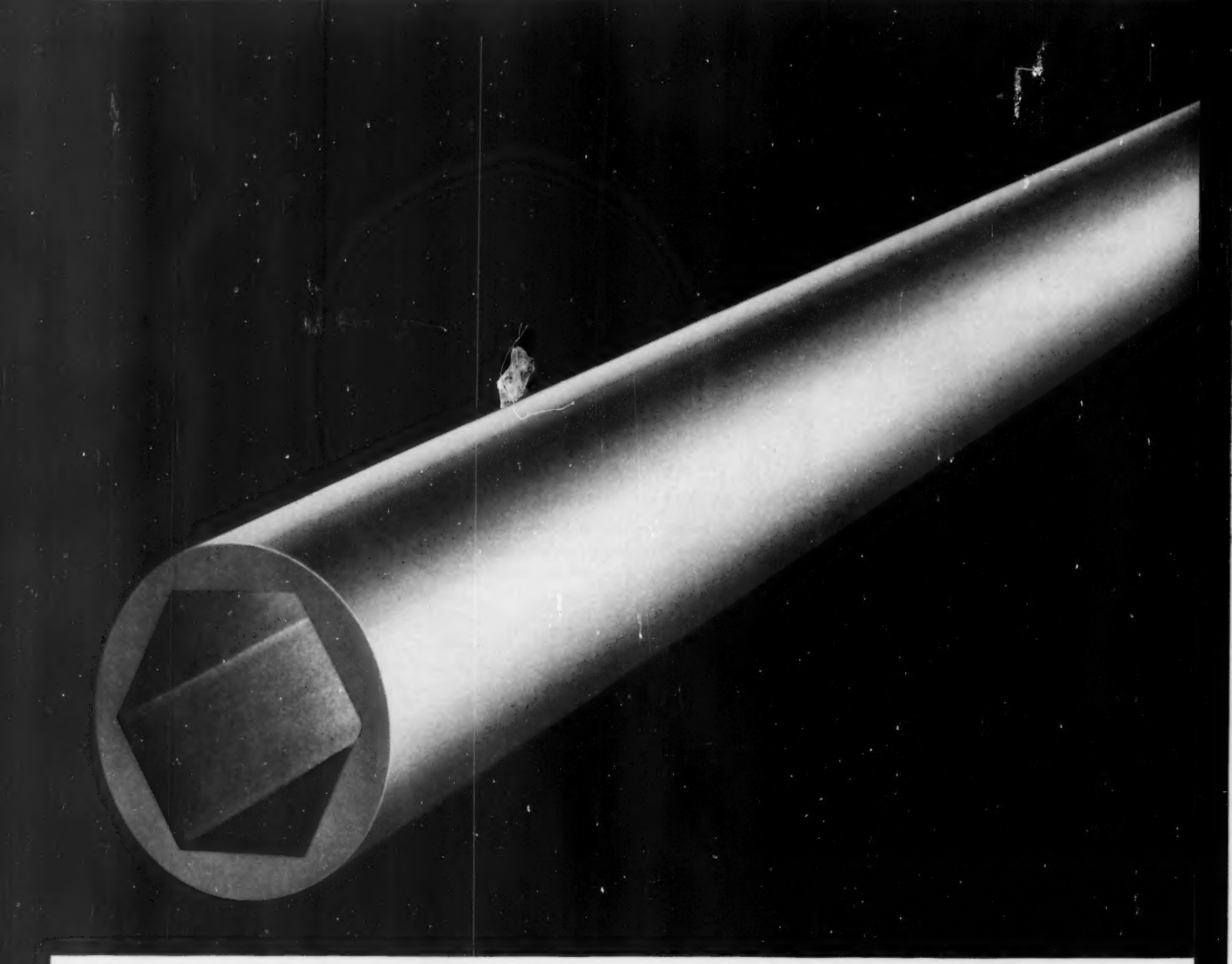

EVER TRIED MACHINING A SPECIAL I.D. SHAPE?

—in stainless steel, with each part 22 inches long, the outside diameter a shade over 2 inches and with tolerances of +.000" to —.010" across the flats?

On jobs like this, there's possible trouble ahead if you start with solid stock, or even round heavy wall tubing. Machining problems, surface finishing, scrap loss, special cutting oils or compounds—added to the original stock cost may make the final cost of the part prohibitive.

There is one sure way of minimizing your production problems and costs involving hollow cylindrical parts and products—*DESIGN WITH B&W MECHANICAL TUBING.*

Before you start your next production run, call **Mr. Tubes** at your nearby B&W Tubular Products Division District Sales Office—let him match tubing steels, types, finishes, shapes and tolerances to your applications—he will show you how to keep final costs low. Or write for bulletins 361 and 340. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

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Seamless and welded tubular products, seamless welded fittings and forged steel flanges—in carbon, alloy and stainless steels.

Circle 406 on page 19

Engineering News Roundup

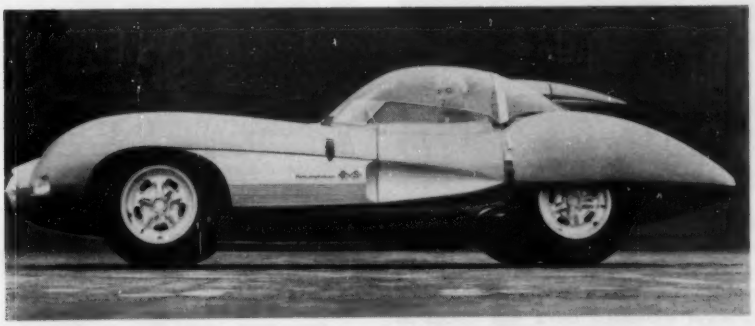
Research Vehicle Emphasizes Light Weight

Corvette Super Sport Car To Set Development Trends

DETROIT, MICH. — A custom-built Corvette Super Sport car featuring a lightweight magnesium alloy body has been under development at the Chevrolet Engineering Center for several months and is now undergoing performance tests. Basically a research project, the Corvette SS will be used to prove the value of engineering advances in engine and transmission design, suspension and braking systems, and the use of new materials. The study will determine whether these features might eventually be refined for use in regular passenger cars.

Extensive use of aluminum in the chassis, a plastic gas tank, four-speed manual transmission, and inboard rear brakes are a few of the innovations to be tested. Wheelbase of the SS-model is 92 in. against the production Corvette's 102 in. Length of both cars is 168 in. A fuel-injected production V8 engine develops over 300 hp with a piston displacement of only 283 cu in. The driver's compartment is built into a 180-lb tubular frame. This construction gives the frame high resistance to bending and torsion and permits the use of lightweight magnesium for the low-slung, aerodynamically-styled body shell. Engine and brakes are air-cooled through ducts from the radiator grille. No engine fan is used. Aluminum parts include cylinder heads, clutch and transmission housings, water pump, and radiator core. The oil pan is magnesium. Results of the weight-saving measures are reflected in the car's dry

FASTEST NAVY FIGHTER, the F8U-1 Crusader, is now with fighter squadrons for operational duty, having recently completed Fleet Introduction Program in record time of 53 days. The Crusader holds the 1956 Thompson Trophy National speed record of 1015.428 mph. It has a two-position wing which enables relatively low speeds for aircraft carrier landings and permits short landing gear which facilitate maintenance. On take-off, hinged wing is at high angle of attack while fuselage is nearly parallel to deck. Weight-savers in the Crusader are after sections made of titanium and a simplified pilot ejection seat of only 30 lb.



A research vehicle for advanced engineering studies in styling and performance, the Corvette Super Sport custom-built car will determine trend in passenger car features. Zora Arkus-Duntov, Chevrolet engineer and European car designer, (shown in cockpit), played a major role in developing the SS-model.

Engine Specifications

Type	V8
Displ. (cu in.)	283
Bore & stroke (in.)	3.875 x 3.0
Fuel induction	Injection
Ignition	12-volt

General Specifications

Radiator	Aluminum, with engine-oil heat exchanger
Plastic fuel tank capacity (gal)	43
Rear axle	DeDion, quick-change differential
Wheels	Cast magnesium
Super Sport tires, 6-ply	
Front	6.50/6.70-15
Rear	7.10/7.60-15

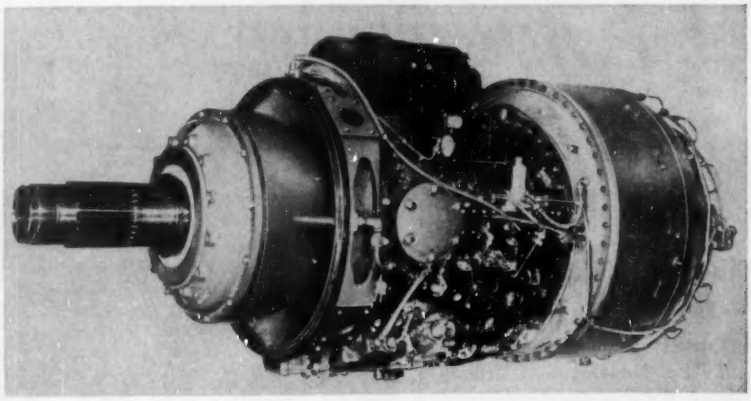
Size and Weight

Wheelbase (in.)	92
Tread (in.)	51.5
Weight, dry (lb)	1850

weight of 1850 lb.

Front wheels are independently suspended. Coil springs, shock absorbers and spring bumpers are assembled as integrated units for installation at each wheel. A link-type stabilizer bar is used for sway control. Brakes are power assisted, having two separate systems operated by the single pedal. Failure of one system will not affect the stopping power. A mercury switch, sensitive to deceleration, can be adjusted to provide a predetermined amount of rear wheel braking. The entire four-speed transmission and aluminum alloy housing weigh only 65 lb.

A prominent feature of the two-passenger cockpit is the head-rest housing which encloses a roll bar rigidly attached to the frame. The body forward of the cowl can be raised for easy access to the engine. The windscreen is plastic.



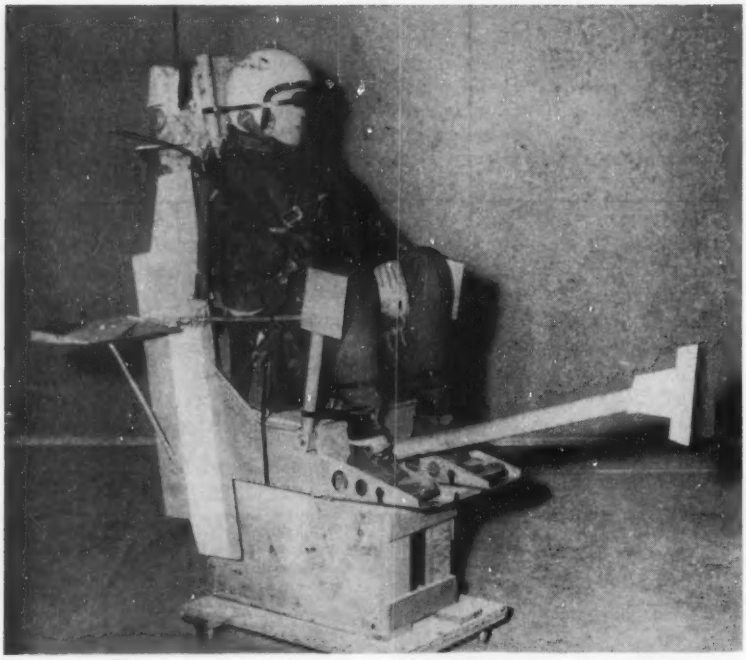
Turboprop version of the Lycoming T55 is claimed the most powerful turbine aircraft engine of its type ever developed in the U. S.

Lightest Engine Adaptable To Helicopter And Turboprop

STRATFORD, CONN. — A free power-turbine aircraft engine recently announced by Lycoming Div. of Avco Mfg. Co., is claimed the most powerful developed in this country and the lightest ever to achieve 1650 equivalent shaft-hp. The new T55 engine is sister to the T53 currently undergoing tests on the Army's H-40 helicopter and Kaman's HOK-1. With slight modification, the T55 can be adapted for marine and industrial use as well as helicopter and turboprop applications.

The engine has been designed for rugged operation and ease of maintenance. Limited use of critical materials assures its availability in event of military emergencies.

Major components of the T55 include a combination axial-centrifugal compressor and external annular vaporizing combustor, a single-stage compressor - driving turbine, and a two-stage free power-turbine. The power-turbine and its associated shafting and reduction gearing are mechanically independent of the compressor and its turbine.



SUPERSONIC GLIDER is the nature of this pilot ejection system developed by Lockheed Aircraft Corp. It should enable safe escape at stratospheric heights and at speeds about Mach 2 or at elevations down to 400 ft and speeds about 850 mph. Features are vertical fins which extend along each side of its back, stub-like wings, and a wind deflector on a 4-ft boom in front of the occupant. The shield causes airflow around the airman; works like automobile bug deflector. Wings, fins and vanes stabilize motion of the seat at high speed; always face the occupant forward. At bailout, seat automatically grips the occupant, then opens his parachute and separates after slowdown. System includes oxygen supply; communication equipment.

Front Cover

Lines of force from a permanent magnet are depicted graphically by artist George Farnsworth on this issue's front cover. How to design permanent magnet assemblies is the subject of Charles Maynard's article starting on Page 122.

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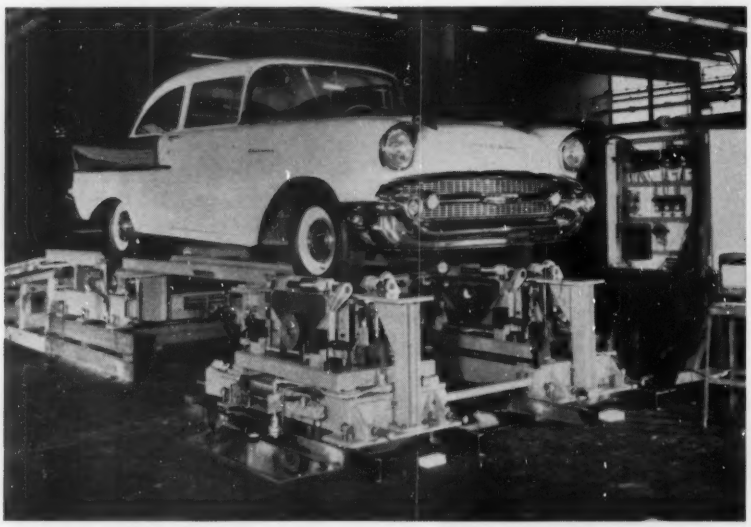
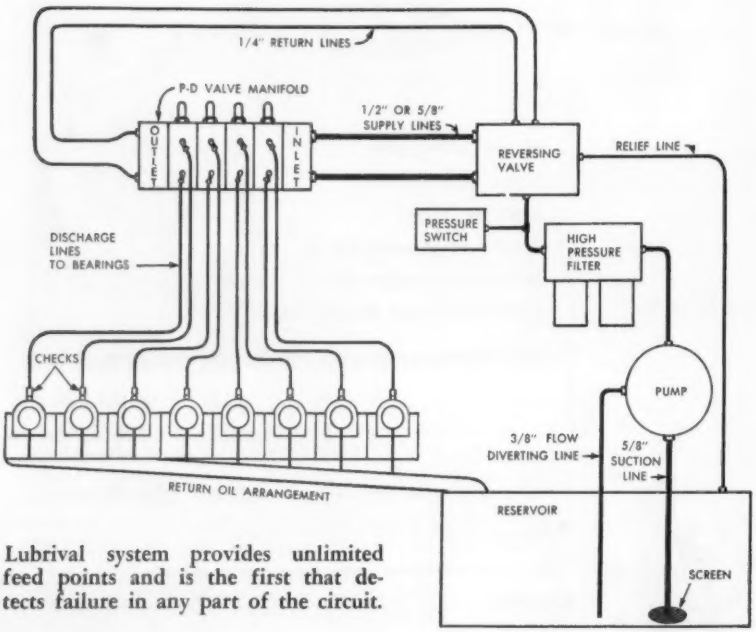


FRONT WHEEL TOE-IN is now set electronically to within 1/64-in. on completely assembled cars with full body deflection. Developed by Chevrolet and the GM Process Development Section, the machine is installed in Chevrolet's Tarrytown assembly plant. While front wheels spin at 30 mph road speed, settings are obtained for both simultaneously or singly. Required corrections are registered on dials. Conventional practice required settings to be taken earlier during assembly, with body weight simulated. When installed, most of the new tester mechanism is below floor level.

Lube System Has Failure Detection; Injection Selection

CLEVELAND, OHIO—Immediate detection of failure of any part of a lubricating circuit, an unlimited number of feed points, and controlled rate of lubricant injection are features of a new circulating oil system by the Farval Corp.

Known as Lubrival, the system



Lubrival system provides unlimited feed points and is the first that detects failure in any part of the circuit.

Topics

Floating oil on water in 9000-ton lots is the aim of a plan proposed by two Cambridge University engineers to transport crude oil. Sixty-foot long nylon oil barges, or "nobs," would be made with an inner container of nylon covered by ¼ to ½-in. thick plastic skin. When filled, the container would be four-fifths submerged and could be towed at a speed of 10 to 15 knots.

• • •

New method of titanium production, now in the final pilot plant development stage, is announced by Stauffer Chemical Co. Titanium sponge is being produced from titanium subchlorides which are, in turn, produced from titanium tetrachloride. The process probably can also be applied to other metals such as columbium, tantalum and zirconium.

• • •

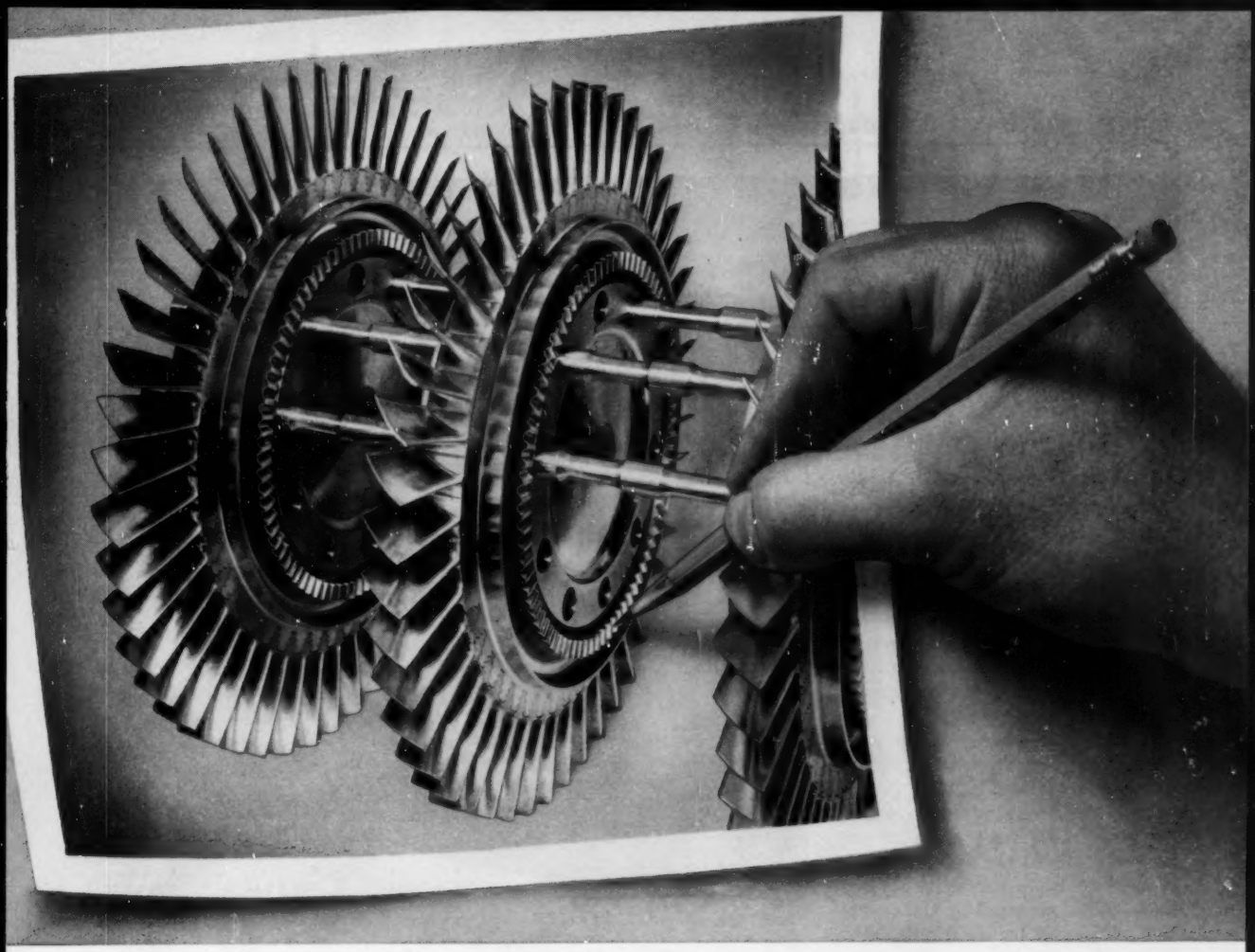
Missile with a message, instead of an explosive charge, was designed by Cook Research Laboratories for communication to ground troops or civilians inaccessible by conventional radio transmitters. The loudspeaker system can be dropped from altitudes up to 60,000 ft. A parachute is released at a preset altitude, a nose cone over the loudspeaker horn snaps off, and at 4000 ft the sound begins operating. In a recent test a recorded message was understandable well outside a half-mile diameter area.

• • •

Three hundred different price tags are attached to 1957 American automobiles, according to *Ward's Automotive Reports.* Sedans account for 96 different-priced models; hardtops, 95; station wagons, 72; convertibles, 27; and coupes, 10. The average standard equipped 1957 car costs $2749, exclusive of taxes.

• • •

Hot box spotter, a small electronic device mounted outside and parallel to railroad tracks, records the temperature of every journal box on a passing train. A recording above a certain temperature actuates warning equipment and indicates the exact location of the overheated journal box. Detector units, developed by Servo Corp. of America, have infra-red lenses mounted at a 45-deg angle to a train's axle journals.



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They have done so for scores of manufacturers, by reducing machining time, by saving time in assembly and by permitting more compact design.

CURVIC Couplings are extremely accurate toothed connections which combine the functions of driving, centering and alignment.

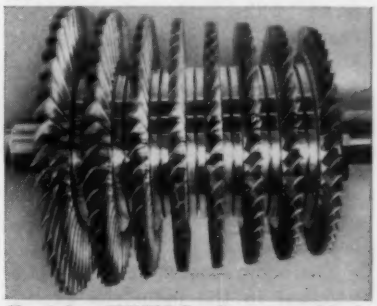
With CURVIC Couplings, complex machine parts can be made in several smaller units and then bolted or otherwise fastened together. Experience has proved that fabrication of many large parts in smaller units has reduced the time spent in machining, simplified final assembly, and reduced over-all manufacturing costs.

And there is no sacrifice of precision —in fact, CURVIC Couplings are so accurate that tolerances in the finished assembly can be held closer than when the part is made by any other means.

CURVIC Couplings are used in such applications as heavy-duty gas turbine rotors like the one shown above, jet engines, crankshafts and camshafts.

In addition to fixed or permanent connections, CURVIC Couplings can be produced in semiuniversal, and in releasing clutch types.

All types of CURVIC Couplings are produced rapidly, economically, and with high precision, on Gleason Cutting and Grinding Machines. If you would like to know more about CURVIC Coupling design or manufacture, the Gleason Works will be glad to consult with you, and to make recommendations about your specific applications. Write for our booklet.



Here is how CURVIC Couplings are used in the production of an 8-stage heavy-duty gas turbine rotor, holding it in perfect alignment under the severe stresses encountered at high speed.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

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Circle 408 on page 19

British-built Ford Squire station wagon, left, features 41.5 cu ft of load space on a wheelbase of only 87 in.

Piston displacement of the Consul, right, has been boosted to 104 cu in. Overdrive is optional.

monitors its own operation by means of a mechanism which warns of pressure changes due to line block, broken lines, or frozen bearings.

A variable delivery pump controls the rate of lubricant injection at bearing points. Oil is forced through a reversing valve which feeds alternate inlet ports of the manifold measuring valves. Each measuring valve serves two bearings, and is actuated by the operation of the one before it. Changes in oil viscosity have no effect on valve delivery. Measuring valves are available in two capacities. Manifold size is governed by the number of bearing points in the application.

British-Built Fords Develop American Accent

Single-Unit Construction Results in Roominess

NEW YORK, N.Y.—Many features of British-built Fords are expected to make the line highly competitive with U.S. light cars. These Fords built overseas are currently bidding for a larger share of the U.S. market. Recent additions to the line offered by Ford Motor Co. Ltd. bring the total to five conventional models and two station wagons in a variety of dimensions and power plants. All have been designed and built for ease of service and maintenance. Engines and chassis are scaled-down versions of U.S. Ford counterparts.

Bolts, nuts, and thread sizes are SAE standard throughout. No special tools are needed. British Fords have an authentic American look. All have compact wheelbases, Lancia-type independent front suspension, good handling qualities and unusual braking stability.

Anglia and Prefect models are powered by a 71.5-cu in. refined Model A power plant with side valves. A similar car, the Consul, has an overhead-valve, four-cylin-

Engine Specifications

	Anglia and Prefect	Consul	Zephr	Zodiac
Type	SV	OHV	OHV	OHV
No. cyls.	4	4	6	6
Bore and stroke (in.)	2.5 x3.64	3.25 x 3.13	3.25 x 3.13	3.25 x 3.13
Displ. (cu in.)	71.5	103.9	155.8	155.8
Comp. ratio	7.0 to 1	7.8 to 1	7.8 to 1	7.8 to 1
Bhp, max	36 @ 4500	59 @ 4200	86 @ 4400	86 @ 4400
Torque, max (lb-ft)	52 @ 2500	92 @ 2000	132 @ 2000	132 @ 2000
		Size		
Wheelbase (in.)	87	104.5	107.0	107.0
Length (in.)	151.25	172.15	178.5	180.55
Width (in.)	60.62	68.6	68.87	68.87
Height (in.)	58.75	61.5	62.0	62.0

Top Designers To Be Heard at Second Design Conference

Papers Prepared for Mechanical, Electrical, Materials Sessions

CLEVELAND, O. — Thirty-three speakers, drawn from the top levels of the nation's design engineers, will lead discussions at the Second Design Engineering Conference at the New York Coliseum, May 20-23.

The conference is being held in conjunction with the Second Design Engineering Show. Sponsor of the conference is the machine design division of ASME.

The show, one of the most phenomenal in the industrial exposition field, will be among the five largest annual industrial expositions of 1957 despite the fact that it was held for the first time only last year.

William F. Ryan, ASME president, and vice-president and senior consulting engineer, Stone & Webster Corp., Boston, will deliver the principal address at a banquet at the Hotel Sheraton Astor, May 23.

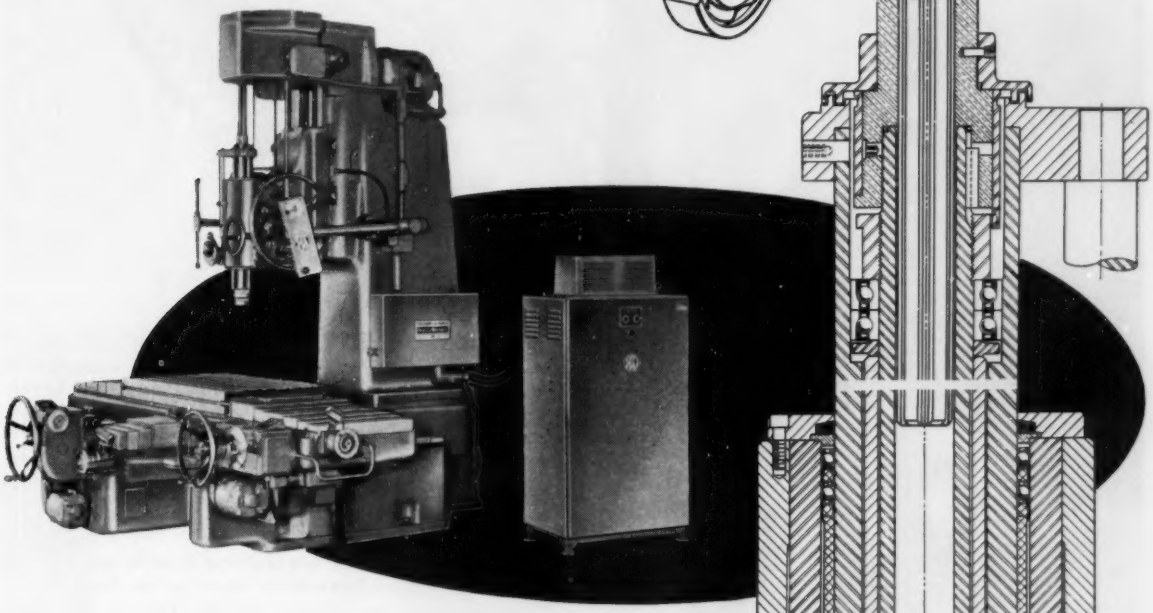
Conference sessions will consider such problems as procedures in developing new designs and other subjects classified under the electrical, materials and mechanical aspects of design engineering.

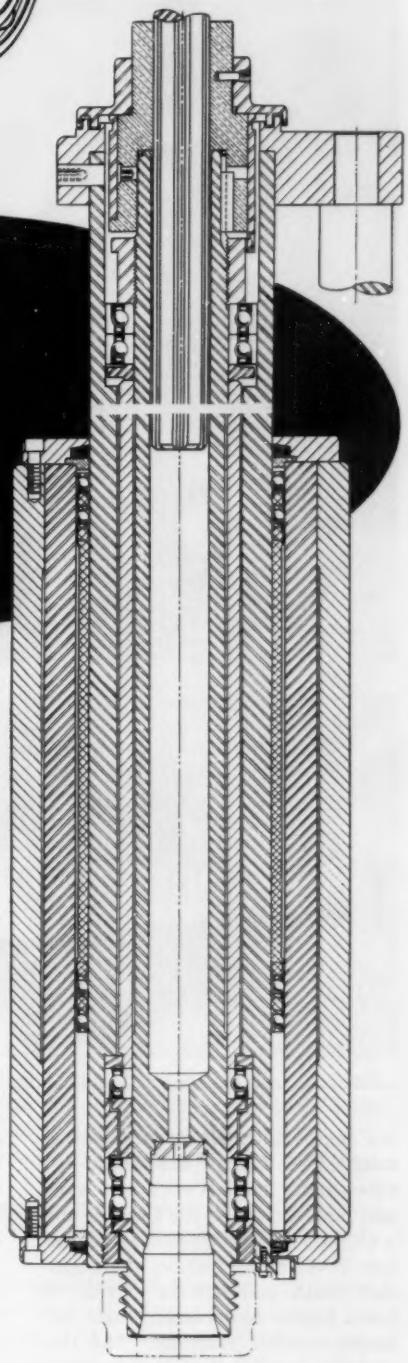
Almost every major company in the U.S. will be represented among the show visitors, and there will be many visitors from foreign countries.

FACTS

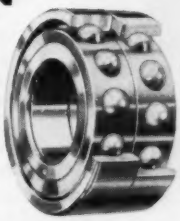
about

NEW DEPARTURE BALL BEARINGS





INVESTMENT IN PRECISION



New Departure Duplex ball bearings are available in a complete range of sizes and series and are made to the finest precision tolerances.

No finely built machine entrusted with cutting metal to extremely small tolerances can be any more precise than the bearings on which its major rotating parts depend.

That's why you'll find this exquisitely accurate Jig Borer Spindle is mounted on New Departure preloaded duplex *ball* bearings. These bearings assure *permanent precision* through a wide range of speeds and feeds.

As a further accuracy feature, the hardened, ground and lapped spindle quill moves on a large number of preloaded steel balls, thereby eliminating any clearances, however small, that would otherwise be required. For more details on New Departure preloaded duplex ball bearings, send for Catalog S.

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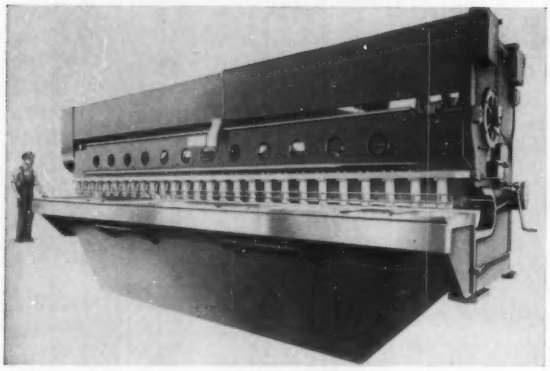
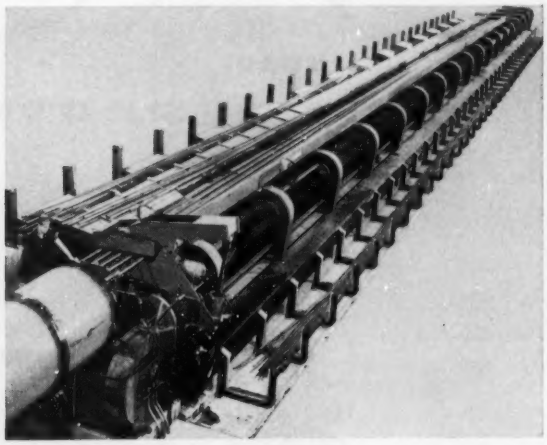
BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

Circle 409 on page 19





(Above)

LONGEST DRAWBENCH in the brass and copper industry can draw five tubes at a time to a maximum length of 210 ft. The machine is installed in the Cleveland mill of Chase Brass & Copper Co. Overall machine length is 400 ft. Powered by 500-hp motor, it puts load of 150,000 lb on dual chain to draw tube at speeds varying between 110 and 330 fpm.

(Left, above)

LARGEST PRESS of triple-action type is one of two which now form large body parts at the Ford Motor Co. stamping plant, Chicago Heights. Built by Hamilton Div. of Baldwin-Lima-Hamilton, the presses feature bottom drive construction. Both upper slides are pulled down by slightly stretchable rods which allow production of stampings of varying thickness without blankholder adjustment. Compact for its capacity, press requires 19-ft headroom and 17-ft basement. All controls are inside the press framework.

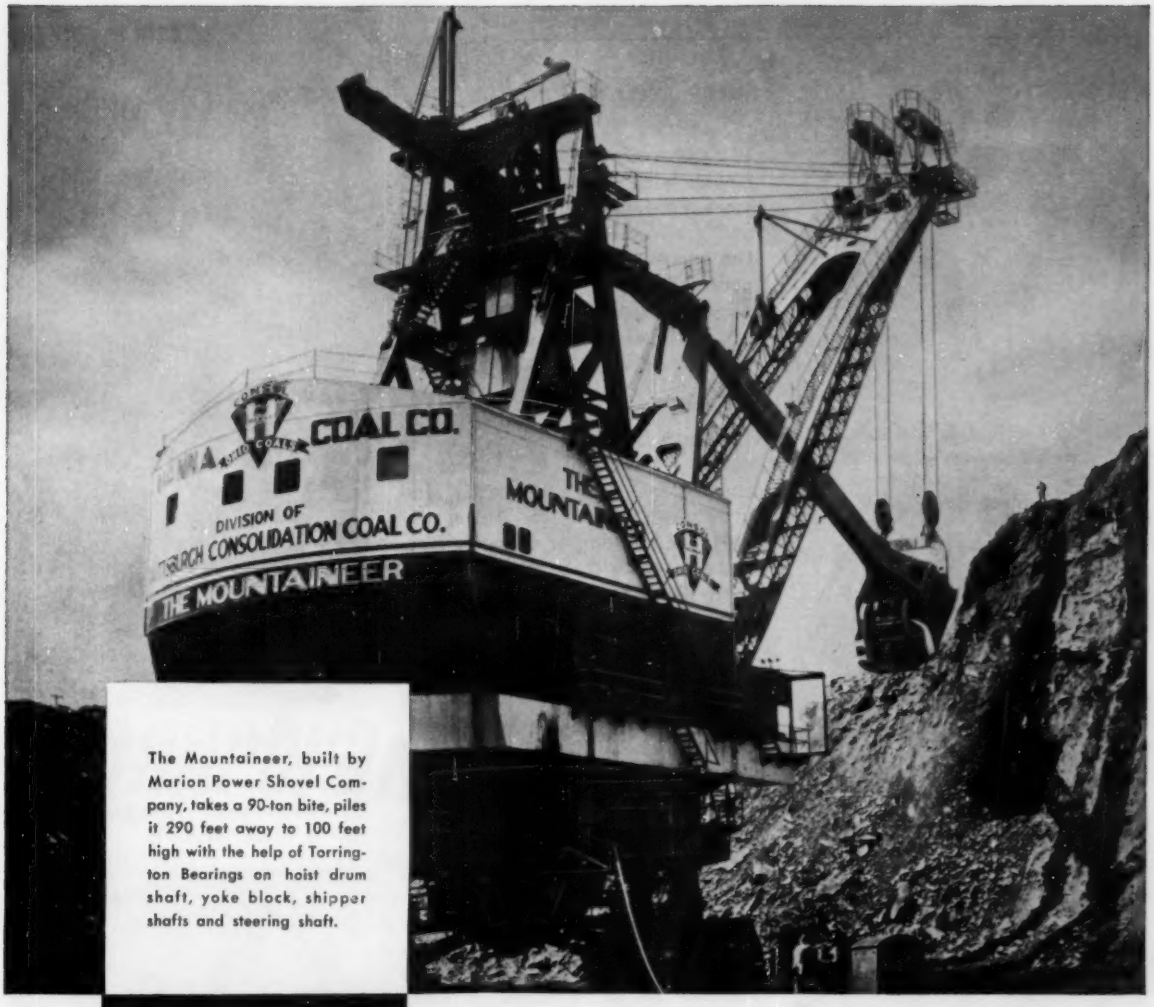
(Left, below)

LONGEST SHEAR of pivoted-blade type built by Steelweld Machinery Div. of Cleveland Crane & Engineering Co. may also be longest made in U.S. It cuts 26 ft of $\frac{3}{8}$-in. mild steel at 30 strokes per minute. It features simple, easy knife adjustment and slitting adjustment mounted on the blade. Blade and hold-down counterbalances, air-operated, are mounted inside machine crown. Bed extends 38 in. below floor level.

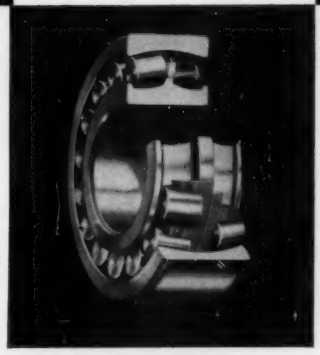
der engine with 104 cu in. displacement. The Zephyr has an in-line six-cylinder engine with the same bore and stroke as the Consul, and a slightly longer wheelbase. A deluxe Zephyr, the Zodiac, offers special finish and bolt-on extras. It has a higher compression ratio and better throttle response. The line includes a pair of station wagons, the Escort and Squire, which are small but roomy versions of American wagons.

Good use has been made of the overall dimensions; the Consul and Zephyr accommodate six adult passengers. These models are 2 to 3 ft shorter than the Dearborn Ford and Mercury, and 9 in. narrower. Roominess is the result of single-unit fabrication without chassis. The Consul, Zephyr, and Zodiac are only 80 lb heavier despite the increase in passenger and luggage space. All models have pendant-type clutch and brake pedals. Bodies have been designed for production by automation.

National Fluid Power Association held its 1957 Annual Meeting in Hollywood, Fla., March 13 to 15. Officers elected for the coming year are: Pres.—R. J. Murphy, sales manager, New York Air Brake Co.; 1st Vice Pres.—J. A. Marsh, vice pres., Rivett Lathe & Grinder, Inc.; 2nd Vice Pres. — L. L. Charlson, pres., Char-Lynn Co.; Treas.—Ellwood G. Peterson, pres., Hannifin Corp. New directors are J. E. Goldring, O. G. Lear, G. R. Pittman.



The Mountaineer, built by Marion Power Shovel Company, takes a 90-ton bite, piles it 290 feet away to 100 feet high with the help of Torrington Bearings on hoist drum shaft, yoke block, shipper shafts and steering shaft.



World's Mightiest Lift Transmitted Through Torrington Bearings

The Mountaineer, world's largest power shovel, transmits its mighty lifting power – 250 tons – through two Torrington Spherical Roller Bearings on the hoist drum shaft.

Here these bearings operate smoothly at full capacity despite shaft deflections. Four other Spherical Roller Bearings are used in the yoke block to eliminate need for precise alignment of separately bored parts. In all applications, advantages of accurate roller-to-race conformity and positive roller guidance through the integral center flange contribute to long, maintenance-free service life.

To carry thrust of helical gears on shipper shafts and of the steering screw shaft, four Torrington Roller Thrust Bearings are used in each of these assemblies.

Not only in power shovels, but in all kinds of heavy-duty equipment, Torrington Bearings have proved their efficiency and long service life. *The Torrington Company*, South Bend 21, Ind.– and Torrington, Conn.

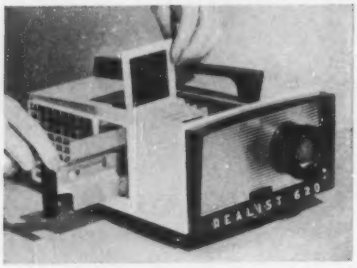
TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

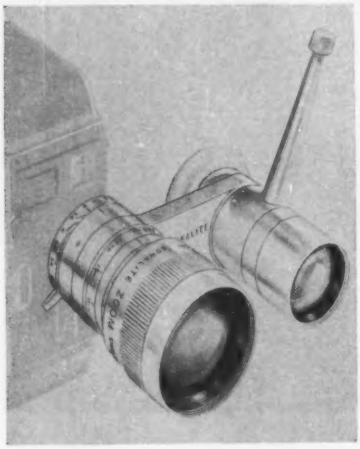
SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

Circle 410 on page 19

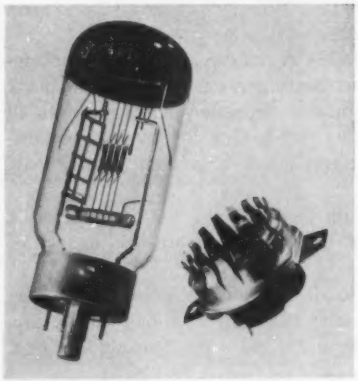
Automatic Features, Better Lamps Seen in Products at International Photo Show



Small size, high style and low price are intended to make Realist 620 projector attractive for home use. The 9-lb projector uses new 300-w horizontol lamp, receives 2¼-in. transparencies; 35-mm slides.



Zoom effect—the rapid change of scope of scene, as in telecasts of sports events—is readily obtained with this Ednalite f/1.9 T.V. Zoom Lens for 8-mm movie cameras.



Compact design and small tolerances of newest Sylvania Tru-Focus projection lamp permit corresponding improvements in projectors.

WASHINGTON, D. C. — More home movies with sound accompaniment, more home processing of color film, and more automatic operations in the exposure of film and copy papers—these are current trends in the field of photography evidenced by displays of new equipment at the recent International Photographic Exposition in Washington, D. C.

Manufacturers now offer movie cameras that set their own exposures and wind themselves. Improvements in projectors even permit good showing of damaged film. A growing trend is the use of magnetic sound strip applied to silent film and reproduced by a sound head in the projector.

The industry notes too that greater numbers of amateurs are using supplemental light. This accounts for a record consumption of flash bulbs last year and growing popularity of electronic flash devices. New lamps pack more light in less space.

Particular new products and materials are:

Automatic exposure control is featured in a new movie lens by Elgeet Optical Co., Inc. The f/1.9 lens is coupled to an accurate exposure meter. The user need only sight the camera and match an arrow with a floating needle.

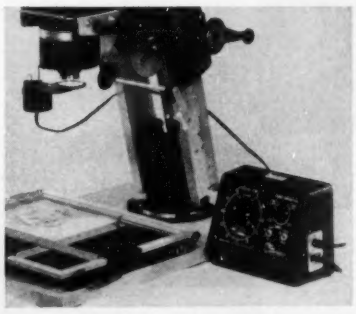
Portable electronic flash unit, introduced by Graflex, features light weight and low cost. Claimed exclusive are its adjustable reflector, adjustable mounting clip, and wired shoe adapter for certain cameras which have internally wired flash shoe.

Line of 16-mm motion picture cameras, medium-priced and spool-loading, comprise the 240-series by Bell & Howell. Features are an automatic film-threading mechanism; a constant-speed, easy-winding, spring motor that gives 32-ft film run; 100-ft film capacity; and a selection of five speeds from 8 to 48 frames/second.

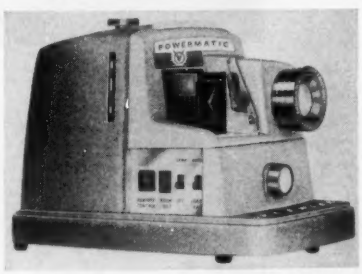
Oscillographic recording films and papers, a new DuPont material called Lino-Flex 1, features durability and dimensional stability. Lino-Flex 1 is introduced mainly for use in oil-well logging, aircraft and automotive testing. Traces on the new film

(*Continued on Page 22*)

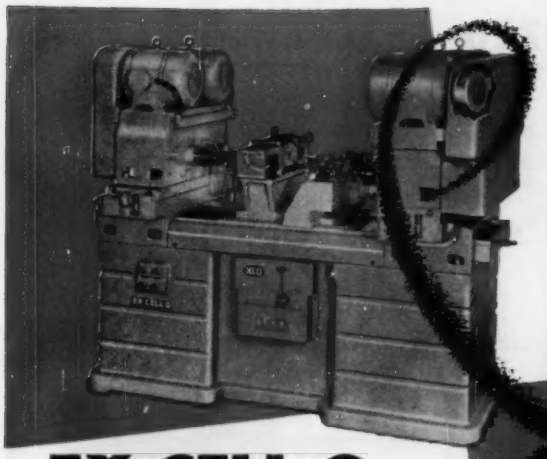
Three-dimensional subjects in exploded-view arrangements can be shot when the Burke & James Princeton-model repro-graphic camera is tilted vertically.



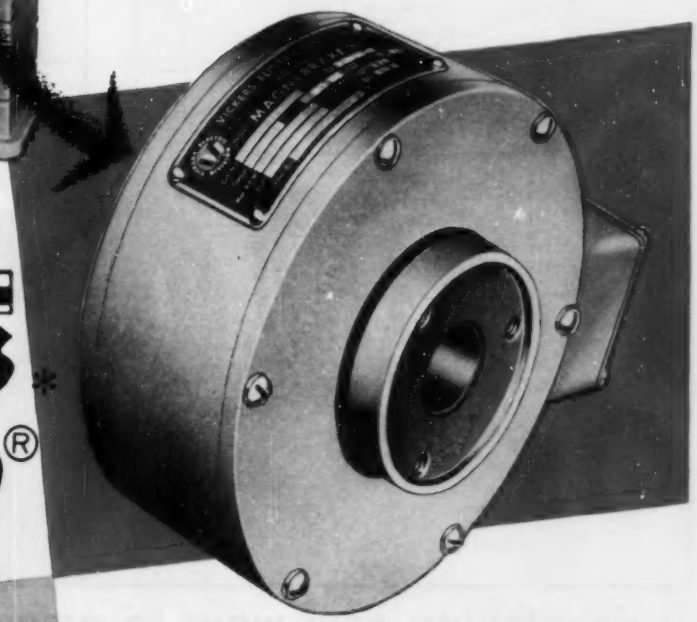
Good quality control of prints made on multiple-contrast papers is obtained with the Simmon Brothers' Omega Electronic Contrast Timer.



Automatic slide exposures, remote controls and quick slide changes make Viewlex Powermatic projector a suitable lecture aid.



FOR SMOOTHER QUIETER and MORE DEPENDABLE PRECISION BORING MACHINE OPERATION



EX·CELL·O uses the VICKERS* Magnebrake®

DRY MAGNETIC-PARTICLE BRAKE

Ex-Cell-O Corporation of Detroit, well-known manufacturer of quality machine tools, equips its precision boring machines with Vickers MAGNEBRAKE, because this unique braking equipment provides the important advantages of . . .

- **LONGER, TROUBLE FREE LIFE,** requiring much less brake maintenance than ordinary friction-type braking systems . . . thereby minimizing and in some instances, eliminating machine down-time. There are no shoes or linings in Vickers MAGNEBRAKES – nothing to wear out – your assurance of far longer, trouble free service life.
- **SMOOTHER, FASTER, QUIETER PERFORMANCE,** without troublesome grab or chatter. Since torque is independent of speed in the MAGNEBRAKE, stops are far smoother . . . thereby preventing transmission of brake vibrations through the spindle and to the work.

Vickers MAGNEBRAKES can serve you with the efficiency, dependability and durability needed for today's faster working duty cycles, higher operating speeds and higher inertia loads. Vickers engineers are thoroughly experienced in the application of industrial clutches and brakes. They will be happy to examine your problem and to offer competent engineering advice, without obligation. Write today for more detailed information.

*TRADEMARK

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VICKERS INCORPORATED a unit of Sperry Rand Corporation

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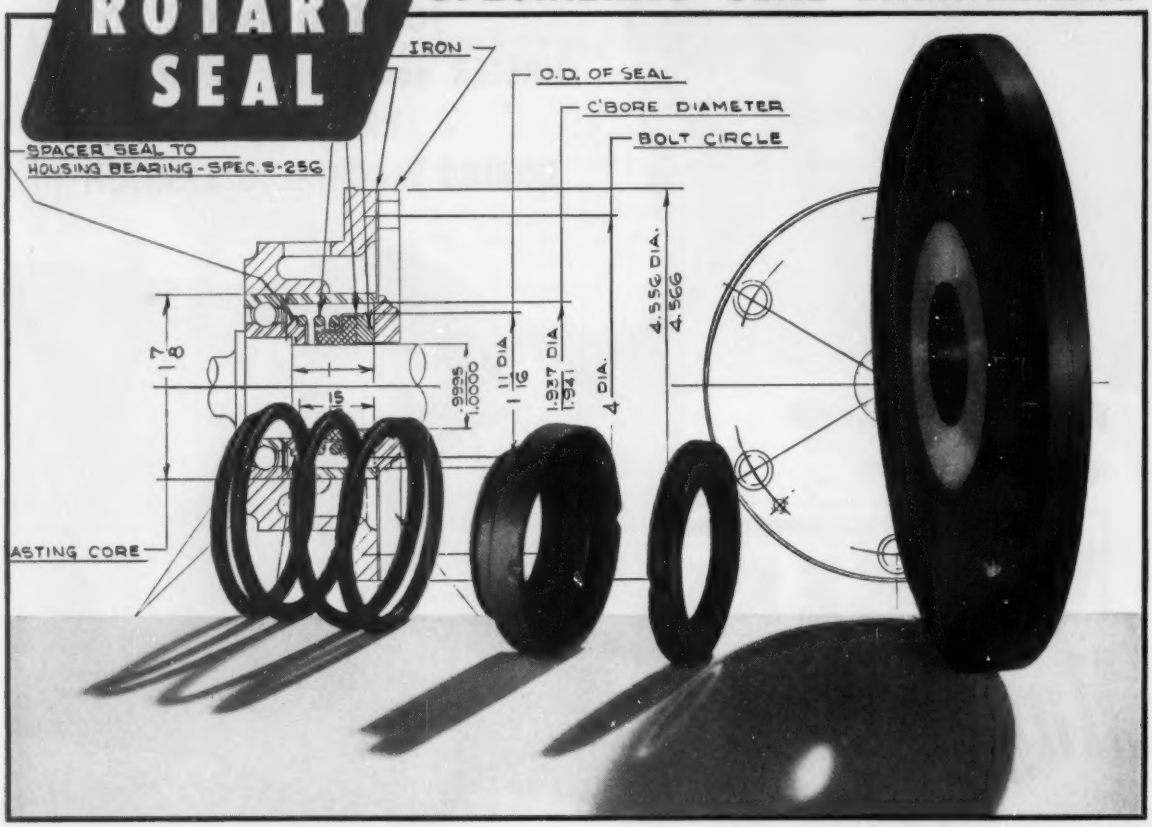

is developing new ways to assure top performance in AUTOMOBILE AIR CONDITIONING COMPRESSORS

Automobile air conditioning, a recent innovation, poses difficult new problems for the compressor maker. The Seal shown represents many months of designing effort, guided by years and years of specialized experience, to produce a Seal that's *right in every detail* — to assure steady unit performance uninterrupted by sealing difficulties.

This Seal, which has been developed for a leading manufacturer of compressors, well exemplifies the skill and patience of ROTARY SEAL engineering. That's our business — solving hard Shaft Sealing problems where production quantities of Seals are involved, by applying the basic ROTARY SEAL principles which opened the way to successful mechanical Shaft Sealing when this company introduced them years ago.

Major assignments for important Seal developments are keeping us mighty busy at present; but if special difficulties are besetting *your* development programs, and production quantities of Seals are involved, we'll be glad to help if we can.

Shaft-Sealing with Certainty

ROTARY SEAL DIVISION
MUSKEGON PISTON RING CO., SPARTA, MICHIGAN

Circle 412 on page 19

MACHINE DESIGN
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SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

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Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 180

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 188

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401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
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423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
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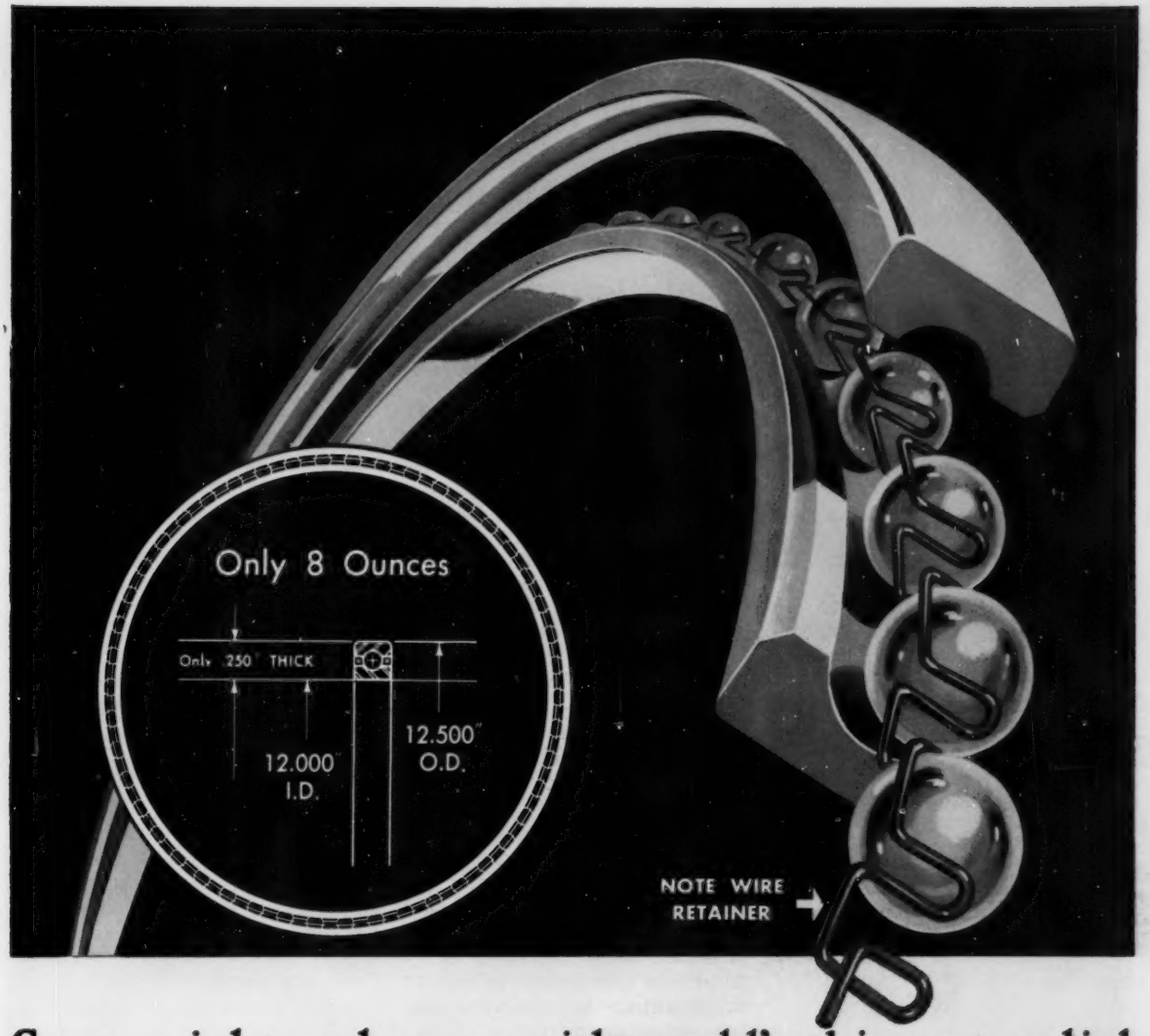


Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim,* high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

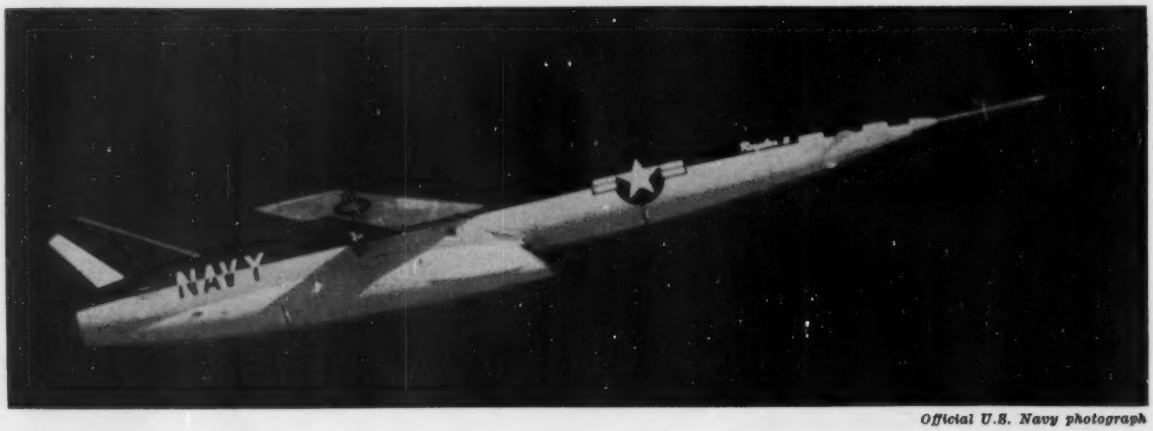
Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K-561

All types of ball and roller bearings — 4" to 120" outside diameter . . .
Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Needle Roller • Ball Radial • Ball Thrust Bearings.



Official U.S. Navy photograph

REGULUS II, 57-ft faster-than-sound guided missile, is shown in one of the first photos released by the Navy. Built by Chance Vought, this flight test vehicle exceeded Mach 1.5 above 50,000 ft. Regulus II is equipped with the Wright J-65 engine; will be powered later by G-E's J-79 complete with afterburner. Also, the missile will be equipped with a nuclear warhead. This newest version of Regulus will utilize a submarine launching system to be designed, built and installed by Firestone Engineering Laboratory, Guided Missile Div. Firestone's first two launching systems are slated for the submarines *Grayback* and *Growler*.

(*Continued from Page* 14)
are readily copied as blueprints or whiteprints.

Fastest photographic film is claimed by Eastman Kodak for its new material Kodak Royal-X Film, Panchromatic, Type B. The extreme speed allows filming of difficult shots like night sports events. Enlargements from the new film up to four or five diameters do not show excessive graininess.

Army Radio To Be Smallest, Lightest Microwave System

Military Channels Now To Carry More Talk

NEW YORK, N. Y.—Military microwave radio equipment, currently under development by RCA for the Army Signal Corps, will be the smallest and lightest of its type ever designed. It is also the Army's first all-transistor voice-multiplexing system.

The multiplexing equipment will enable operators of microwave radio relay systems effectively to transmit numerous signals simultaneously on the same microwave band. The separate channels of communication are combined by the multiplexing system at the point of origination, transmitted through the microwave system as a single combined wave, and unscrambled at the receiving station for delivery to specific destinations.

The system is a time-division, pulse-position type which provides 23 communications channels. Two systems can be used in combination to furnish up to 46 channels.

Total weight of the new system will be 85 lb. It will be assembled in a case measuring 13 by 17 by 20 in., and will operate on only 55 w. It will use 260 transistors and 400 semiconductor diodes.

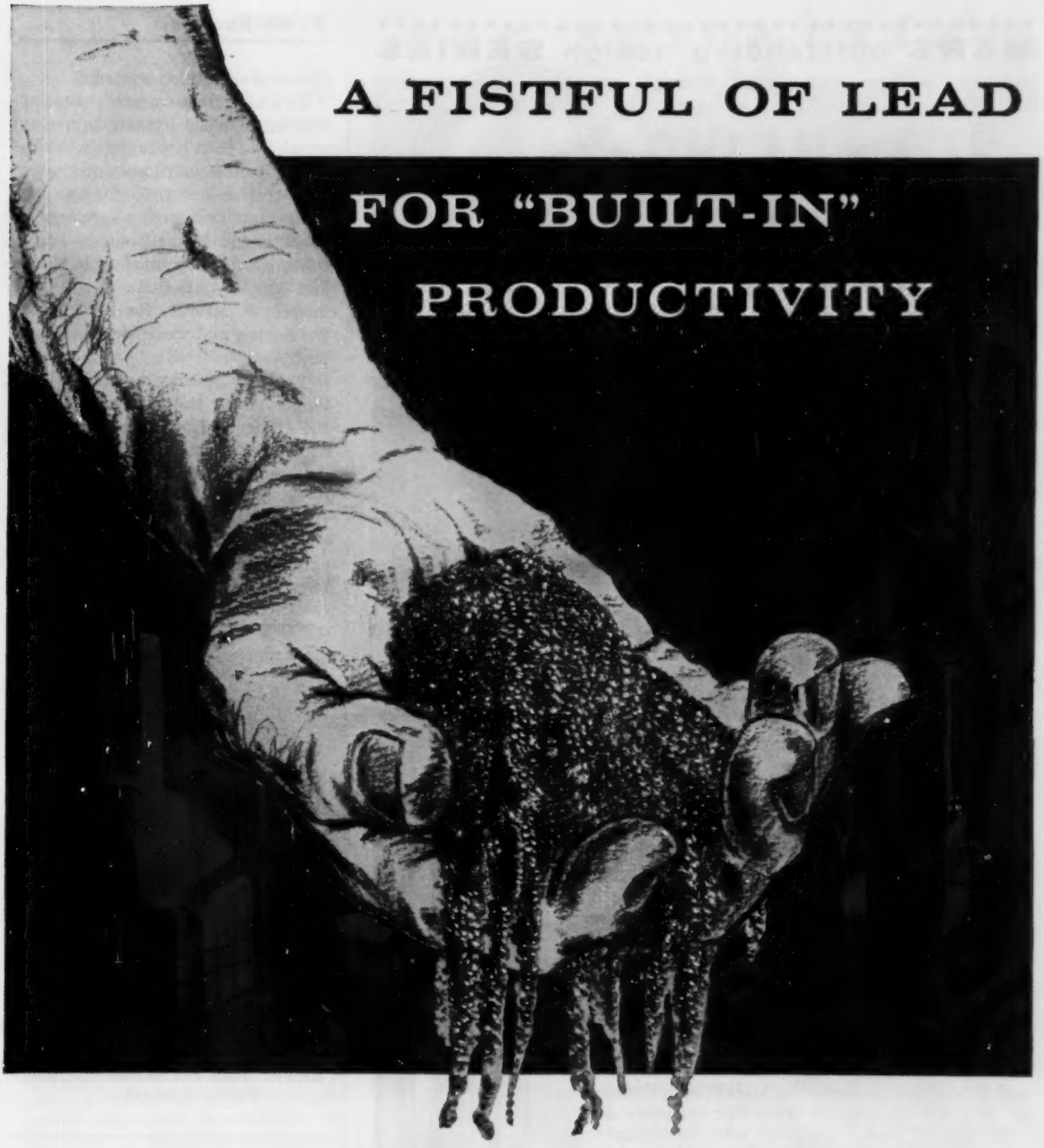
CYTAC Navigation System To Aid Air-Sea Traffic

NEW YORK, N.Y.—'Round-the-clock all-weather coverage for the U.S. and adjacent seaways is provided by an air-sea navigation system recently announced by the Sperry Gyroscope Co. Known as CYTAC, the new system requires only 15 ground transmitters within the U.S. compared to 1200 for more

RUMBLE SEAT SPORT MODEL is the Shooting Star by Switzer Craft, Inc. Bucket-type seats accommodate two passengers behind twin windshields. Hatch lifts up to form rumble seat for two more in front of 40-hp engine. Corrective spray rails give sport-car handling on high-speed turns. Seat springs take shocks in choppy water. Overall boat length is 15 ft; beam 60 in.; depth 26 in. Transom width at water line is 50 in.; transom height at center is 16 in. Approximate weight is 280 lb; maximum load 600 lb.

A FISTFUL OF LEAD

FOR "BUILT-IN" PRODUCTIVITY



Controlled additions of lead, introduced when the ingots are teemed, produce steel with vastly superior machining qualities compared to same steel unleaded. Leaded alloy and carbon are freer machining, permit faster feeds and speeds and greatly increase tool life. They cut clean and with a fine finish which frequently eliminates the final machining operation. These better machining qualities add up to a kind of "built-in" productivity that can mean substantial production line savings for you.

If you would like to see for yourself what "built-in" productivity can mean in your operation, ask us to lead half of your next Aristoloy order. Our field metallurgist is also at your disposal—ready to work with you in selecting the best leaded grade for the job.

For complete information, call the Copperweld office in your nearest major city, or write direct.

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY

Steel Division • Warren, Ohio

EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N.Y.

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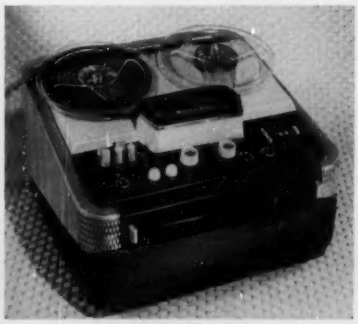
News Roundup

immediate planned systems.

CYTAC's features are characteristic of a pulsed hyperbolic system which has been predicted as the future common solution of high-density traffic control. It has the range and accuracy necessary for common use by helicopters, transcontinental and transoceanic planes and ships. All-altitude coverage makes it useful for low-flying, fixed-wing and vertical-takeoff aircraft.

The new Sperry system achieves longer range than its predecessor, the standard Loran system, by using lower frequency transmission. An automatic shipborne-airborne receiver was developed for use with the new system. However, the standard Loran receiver-indicator can be adapted to CYTAC with a two-tube frequency converter.



TWIN SPEAKERS and public address control are features of this new Bell & Howell tape recorder. Five operating butons are labeled Stop, Forward, Rewind, Play and Record. Tone can be Normal, Monitor or Public Address.

Economical Nuclear Power Forecast For 1980

Technical Advances To Lower Costs Periodically

WASHINGTON, D.C.—Atomic power plants are expected to achieve costs of 6 to 7 mils per kw-hr by 1980, making nuclear power competitive with that of conventionally fueled plants in almost all parts of the U.S. These figures were forecast by W. K. Davis, director, and L. H. Roddis Jr., deputy director of the AEC Division of Re-

actor Development in a joint report presented recently to the National Industrial Conference Board in Philadelphia.

Plants going into service during the years 1957 through 1959 will be experimental and achieve costs from 20 to 50 mils per kw-hr. Estimated total generating capacity for this period is 130,000 kw.

Experience gained in the design, construction, and operation of these early plants would pave the way for the first large-scale generation of industrial power during the years 1960 through 1964. These plants are expected to achieve costs of 10 to 13 mils compared to the 4½ to 9-mil rate for conventional power. Total output for the plants of this period, including those of experimental vintage, is estimated at 2.5-million kw. High cost factors include obtaining safety, the use of expensive material because of the lack of cheaper substitutes, and short-life fuel elements.

Further technical advances will introduce a second generation of nuclear power during the years 1965 through 1967. Capital costs may be expected to approach a competitive level with those of conventionally fueled plants. A 9 to 11-mil rate at this time will be competitive with conventional power costs in some parts of the U.S.

An expansion phase is expected in 1967 in which the added nuclear capacity should reach 8 per cent of the total additions. The percentage should increase sharply until in 1980 two-thirds of all capacity added will be nuclear. On the basis of these expectations, a cost of 6 to 7 mils will be competitive with the rate for conventional power in all parts of the U.S.

Tough New Silicone Rivals Natural Rubber

Stretches Five Times Size Over Wide Heat Range

MIDLAND, MICH. — Mechanical strength and abrasion resistance like conventional organic rubber are featured properties of a new

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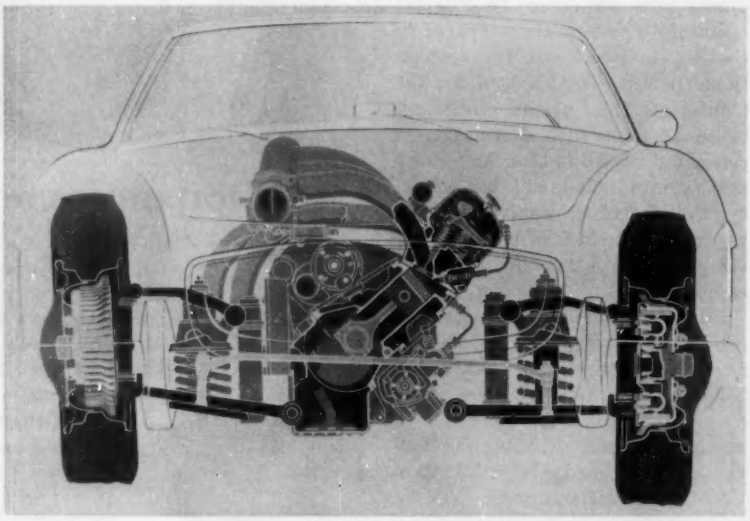
silicone compound introduced by Dow Corning Corp. Designated Silastic 916, the new material is claimed the toughest, strongest heat-stable silicone rubber ever developed. The new Silastic also has high dielectric properties characteristic of other silicones.

Silastic 916 is also nontoxic, serviceable at extreme low temperatures, and is easily processed. It can be milled and compounded after shelf-aging almost indefinitely. Suitable for molding, extruding or calendering, it can be hot-air vulcanized. It also remains firm in the unvulcanized state, thereby minimizing possible distortion of extruded shapes prior to curing.

Typical properties for Silastic 916 include tensile strength in the range of 1500 psi and tear strength of approximately 200 ppi. Elongation is over 500 per cent and durometer hardness rating is from 50 to 60 on the Shore A scale. Useful temperature range of Silastic 916 is −130 to over 500 F.



Gasoline fuel injection is standard in the Mercedes-Benz 300SL Roadster. The 250-hp canted six-cylinder engine gives top speed of 155 mph.

Canted Engine Permits Lower Hood in Sport Roadster

Mercedes-Benz Model Also Has Fuel Injection, Big Brakes

NEW YORK, N. Y.—An improved version of the Daimler-Benz sports car, the Mercedes-Benz 300SL Roadster, will be available in the U.S. this summer. Among other major characteristics, it incorporates racing car roadability and extensive safety features.

The 300SL Roadster's open body has front-hinged doors, body-contoured bucket seats, special ventilating fixtures and a folding top. Tubular construction gives the frame high rigidity and resistance to bending and torsion. The six-cylinder engine is equipped with fuel injection and develops 250 hp at 6200 rpm with a compression ratio of 9.5 to 1. An oversize turbo-braking system permits full use of engine power safely. The engine is canted, which allows for a lower hood design. Top speed is 155 mph. Overall height of the

Engine Specifications

Type	OHV, overhead camshaft
No. cyls.	6
Displ. (cu in.)	183
Bhp, max	250@6200 rpm
Comp. ratio (100-octane fuel)	9.5 to 1
Torque, max (lb-ft)	228@5000 rpm
Ignition control	Auto. centrifugal advance

Size and Weight

Wheelbase (in.)	94.5
Ground clearance (in.)	5.1
Length (in.)	177.8
Width (in.)	70.5
Turning rad. (ft)	37.5
Weight, dry (lb)	2756

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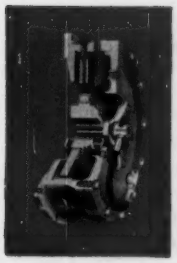

BIRDSBORO found

STEEL FDRY. AND MACHINE CO.

WICHITA

CLUTCHES and BRAKES

☆ *Practical to apply* ☆ *Reasonable in price*

☆ *Supported by good engineering and service*

OTHER OUTSTANDING FEATURES

- SAFER OPERATION
- COOLER RUNNING
- NO ADJUSTMENTS
- NO LUBRICATION
- EXTREMELY LONG LIFE
- FASTER ENGAGEMENT AND DISENGAGEMENT
- VERY LOW MOMENT OF INERTIA
- EASIER MAINTENANCE

Pictured is a 500 ton Birdsboro Up-and-Down Shear for cutting blooms and beam blanks hot. The Wichita Clutch is mounted directly on the flywheel. The Wichita Brake is on the opposite end of the shaft.

Birdsboro Engineering Dept. states, "We were losing sales on shears until we installed WICHITA CLUTCHES. For some time we had been trying to apply air-operated friction type clutches to our shears, but only WICHITA Clutch Engineers were able to give us a clutch that was satisfactory."

"Wichita Clutches have benefited our equipment most because they eliminate the need for either unsatisfactory mechanical jaw-type clutches or expensive direct drive start and stop."

WICHITA ENGINEERS

Brehm-Lahner, Inc., Detroit, Mich.
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co. (Main Office), Avon, Conn.
Smith-Keser & Co., Philadelphia 44, Pa.
Smith-Keser & Co., New York, New York
Frank W. Yarline Co., Chicago, Ill.
Power Rig & Equipment Co., Inc., Long Beach, Calif.
Andrew T. Label, Denver, Colorado
Robert R. King Co., Cleveland, Ohio
Dominion Power Press Equipment, Ltd., Burlington, Ontario, Canada
Industrial Air Controls Co., Fort Worth, Texas
Allied Transmission Equipment Co., Kansas City 8, Missouri

WICHITA Clutch COMPANY, INC.

WICHITA FALLS, TEXAS, U.S.A.

News Roundup

new model is 51 in.

Standard equipment includes a wraparound windshield, electric wipers coupled to a foot-operated windshield washing system, combination Acoustilight-horn, padded sunshades, and an adjustable back rest on the driver's seat. Custom-built luggage, designed to fit the large trunk space, is optional. A new light-control arrangement permits centralized operation of headlights, fog lights, parking and directional lights.

PORTABLE PRECISION is introduced by Allen B. DuMont Laboratories in this new, compact oscilloscope equally suitable for rack mounting or field use. Designated type 402, the unit is 19 by 11⅛ by 5 in.; weighs 27 lb; fits in luggage-like aluminum case with built-in tilt stand. Scope sensitivity is 22 dc mv per in. On the front panel, controls are grouped in "blocks of function" set off in contrasting colors.

Radio, Radar, Computer Now Land Planes in Worst Weather

Navy Automatic Landing System To Extend Carrier Operations

BUFFALO, N. Y.—Radio, radar and an electronic computer are combined in an Automatic Carrier Landing System built for the Navy by Bell Aircraft Corp. Having recently completed land-based tests, ACLS will now be installed on a carrier for trials at sea.

Completely automatic, the system has successfully landed six dif-

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ferent types of jet fighters, large transports, and light commercial aircraft at a number of different bases. It operates in all kinds of weather.

ACLS radar locates an airplane and determines its altitude and position in relation to the carrier deck. An electronic computer determines course corrections transmitted to the plane. A receiver then directs the airplane into the desired flight path. The system takes into account the carrier's movement the instant the plane is to touch the deck. If the airplane is not in the best attitude for a safe landing, ACLS automatically sends the airplane around for another attempt.

The system should improve all-weather operations in the Navy and may also have civilian applications. Combined with a cross-country navigational system, it could make completely automatic flight possible under all weather conditions.

Record Attendance Marks Biggest IRE Show

Transistor Holds Spotlight In Talks, Displays

NEW YORK, N.Y.—Big interest in small parts was observed recently in New York's Coliseum where more than 50,000 engineers and scientists attended the 45th annual convention of the Institute of Radio Engineers. During the 4-day event, guests and members of the IRE attended 55 technical sessions; saw 17,000 pieces of equipment displayed in 800 booths. The feature spot in talks and displays was held by one of industry's smallest components — the transistor. Interest also ran high in printed circuits and microminiaturization. Computers and automation processes presented new and practical applications. Products and materials recently new or improved were:

An electronic mail sorting system developed by the Canadian Post Office in Ottawa was disclosed at one of the sessions. Operators convert the names of villages, towns and streets into a special code for electronic handling.

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TRABON

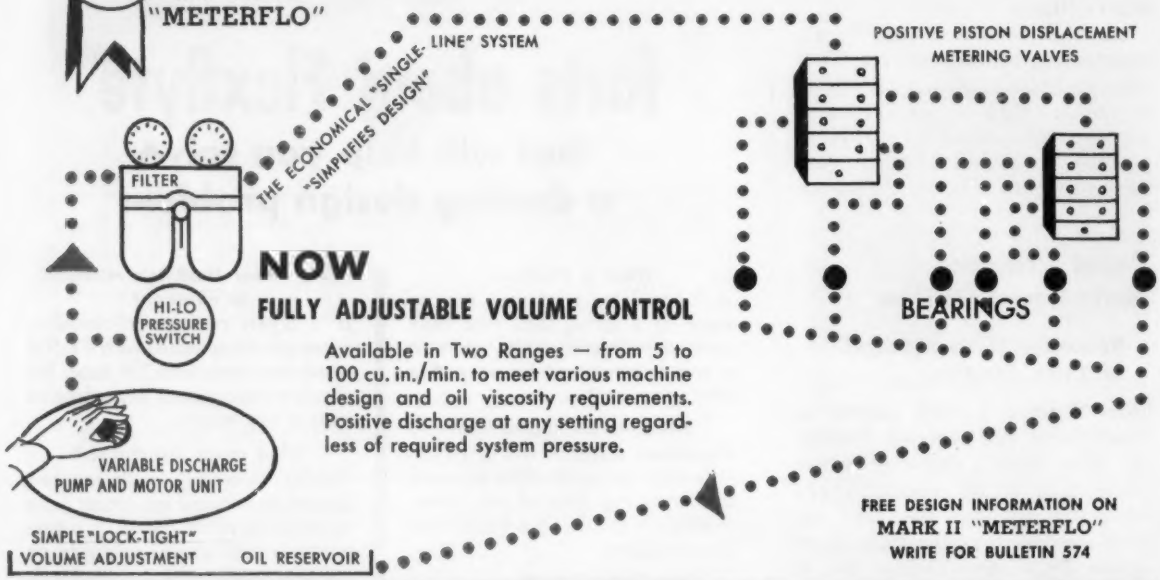
Announces...

MARK II

"METERFLO"

CIRCULATING OIL LUBRICATION SYSTEM

POSITIVE OIL FLOW TO EVERY BEARING UNDER PRESSURE



NOW

FULLY ADJUSTABLE VOLUME CONTROL

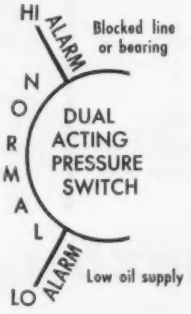
Available in Two Ranges — from 5 to 100 cu. in./min. to meet various machine design and oil viscosity requirements. Positive discharge at any setting regardless of required system pressure.

FREE DESIGN INFORMATION ON MARK II "METERFLO" WRITE FOR BULLETIN 574

PLUS CALIBRATED DUAL PRESSURE SWITCH EQUIPMENT

Compact dual-acting pressure switch now includes calibrated adjustment for simple and ready adaptation to meet all field conditions. "Pressure-dampened" switch and gauge equipment—for longest equipment life and elimination of any momentary "false" pressure signals.

Wide normal operating range assures positive metered quantity **regardless of length of line or varying bearing resistances.**



TRABON ENGINEERING CORPORATION
28815 AURORA ROAD SOLON, OHIO

NOTE TO MACHINE DESIGNERS

- Hi-Pressure dual cartridge filter — a turn of the handle permits cartridge change without stopping system—"quad" ring seal construction for leak-proof operation.
- Wide range metering valve sizes for ultra-fine metering requirements (i.e. exposed sliding surfaces)—plus accurate control over output ratios of 20-1 and higher within the same system.
- Protection against failure of oil to reach bearings for **any** reason.
- Constant positive pressure feed regardless of change in temperature or oil viscosity.
- "Packaged" power units—complete sump, pump, and control units available in any desired combination.

For further economy, non-adjustable units also available.

Metals Matters

Application of metallic coatings to plastic film, textiles and ultimately paper will be accomplished by a new vacuum process. Rolls of Du Pont Mylar have been given a "virtually flawless" metallized surface by the new process, developed by National Research Corp. A roll of material is placed in a vacuum-tight tank, the tank is closed and the air is pumped from the chamber by a system of high-vacuum pumps. When the pressure has been reduced to about 1 millionth of atmospheric, the roll is unwound past a source of molten metal, usually aluminum, heated to over 1200 C. Aluminum vapor condenses on the surface of the film. The ability to evaporate metal continuously for a relatively long time is a key feature of the process.

• • •

New steel for jet engine bearings is made of "99 per cent native" materials. Such an alloy would make possible a supply of these bearings in time of national emergency, according to Republic Steel Corp., producer of the new steel. Principal alloying elements are 3 per cent nickel, 1.5 per cent chromium and 5 per cent molybdenum. Operating temperatures range up to 500 F, and the material recovers its original hardness when cooled to room temperature after heating as high as 1000 F. Bower 315 is used in bearings made by Bower Roller Bearing Div., Federal-Mogul-Bower Bearings Inc.

• • •

Sheathed-tube cores developed by Howard Foundry Co. are being used to produce small, intricately shaped, unlined passageways in aluminum and magnesium alloy sand castings. With the new method, passageways for transmitting oil, fuel, coolant and hydraulic fluids can be internally wrapped around a large cylinder in a continuous line. The core consists of a preformed metal tube sheathed in a flexible refractory sleeve. After the casting is made, the tube is dissolved by a chemical and the sleeve is removed manually.

• • •

Gas turbine engines may be made to operate at speeds far in excess of present models through the use of the metal columbium, or niobium. This is the opinion of Dr. Morris A. Steinberg, head of the metallurgy department of Horizons Inc. Dr. Steinberg points out that if the temperature of application can be increased, the size of the engine can be decreased with no loss in power output. Gas turbine engine materials that withstand temperatures only as high as 1800 F limit the top power output possible. Before columbium can be used as a production material, however, several problems must be solved involving its recovery from ore; separation from a companion metal tantalum; and economical preparation.

• • •

Adding 100 mph to a jet plane's speed should be possible with a material developed by Westinghouse and used to fabricate turbine disks. Westinghouse claims that its new W 545 alloy should permit a 100-degree increase in operating temperatures. W 545 is composed of iron, nickel, chromium, molybdenum, titanium and boron. It is being prepared on a pilot plant scale and is expected to find application shortly in experimental jet engines.

Envelopes marked with the code are then processed automatically.

Explosive exposures as short as one ten-billionth of a second are possible with RCA's special electron tube called an image converter. Images are transmitted electronically from a cathode at one end to a screen at the other end for photographing.

Rotor failure of experimental power plants can be detected an instant before bursting by a process developed by Ford Motor Co. Scientific Laboratory. The method requires the induction of electrical signals into the rotor which are used to trigger a high-intensity light source for photographing the moment failure begins.

Copper-clad laminated plastics were shown by the Formica Corp. These new materials were devel-

(*Continued on Page* 34)

Circle 422 on page 19

GOLD N RING

Units are available in flush-plate or enclosed mountings, and are adaptable for special panel assemblies.

New...

Oil-tight • Water-tight • Dust-tight

Protected against oil and water seepage by Sealtight oil-resistant rubber diaphragm. Rated for 600 volts, AC or DC. Meets requirements of Joint Industry Committee and National Machine Tool Builders' Association.

EASILY REPLACES EXISTING SWITCHES—**Designed for mounting in 1 13/64" diameter holes on standard panel mounting centers, this switch easily replaces existing switches. Accommodates panel thicknesses of 1/16" to 1/4" in 1/32" increments. Full interchangeability of units and their components permits ready adaptation to multiple assemblies.**

Another product of...

National Acme

Circle 423 on page 19

Sealtight CONTROL SWITCH

Made by machine tool builders to machine tool specifications

How often have you, when designing a machine tool, wished for a control station unit designed and constructed "*as a machine tool builder would build it.*"

If you have been so handicapped in the past, you'll want to take a good close look at the NEW Namco GOLD-N-RING Control Station Switch Unit. Built by National Acme, builder of the world's only complete line of bar and chucking automatics, it is the *only* switch made *by* a machine tool builder *with machine tool know-how behind it.*

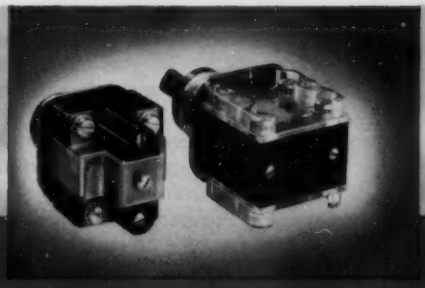
- **It is a heavy-duty switch in every respect.**
- **It is oil-tight, water-tight, dust-tight.**
- **Heavy-duty silver-alloy contact points provide maximum electrical capacity and long life.**
- **Heavy-duty terminal screws, with 3/8" thread contact, prevent stripping during installation and permanently secure wires for continuous trouble-free service.**
- **None easier to install; none more fool-proof.**

For complete details, send for Bulletin ECS-56. Better yet, ask for a representative to bring a switch for your examination.

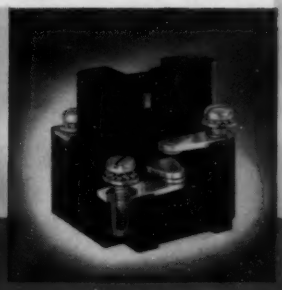
Electrical Mfg. Division • THE NATIONAL ACME COMPANY • Cleveland 8, Ohio

▼ FLUSH PLATES OR ENCLOSURES accommodate any combination of individual push button, selector or pilot light assemblies. Box covers and flush plates are provided with captive screws to facilitate installation. Easy-to-read, interchangeable legend plates lock securely into position.

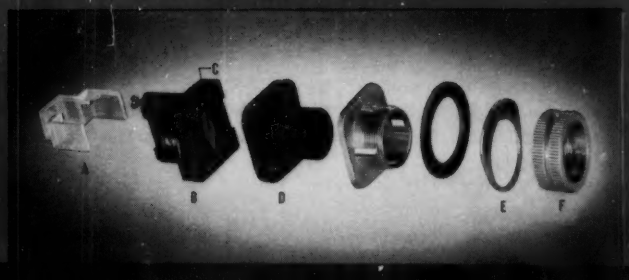
▼ SINGLE AND DOUBLE POLE CONTACT BLOCKS can be used interchangeably with the several types of GOLD-N-RING push button and selector operator heads. Design provides easy access for secure wiring (or use of stake-on lugs) without interference. Fixed and movable contacts are completely enclosed by heavy plastic shields.



▼ BRASS INSERTS molded in block permanently hold stationary contacts. They also provide more thread support for the No. 8-32 terminal screws that are equipped with captive flat and lock type washers.

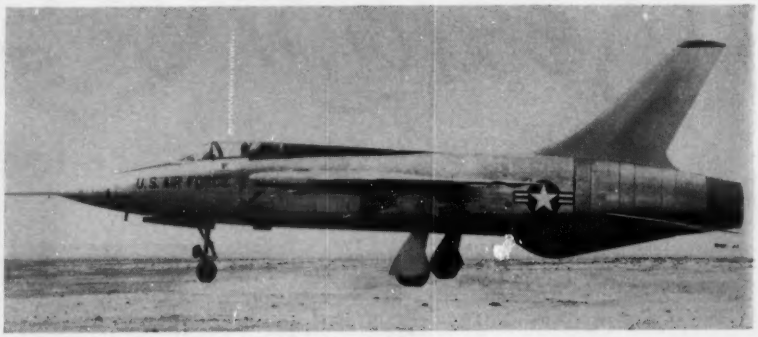


▼ BUILT AS A MACHINE TOOL BUILDER WOULD BUILD IT! Plastic shields (A) completely enclose contacts. Main block (B) is unit-molded to assure alignment and simplify assembly. Fully guided plunger (C) of cross-head design, prevents binding. Oil-resistant rubber diaphragm in operator head (D) completely seals out oil, water and dust. Easy-to-read legend plates (E) lock into position by "GOLD-N-RING" (F).



▼ INTERCHANGEABLE "GOLD-N-RING" COLLARS come in 3 different heights. Buttons can be made either extended or flush type merely by changing collar. Buttons are of non-fading glass-filled polyester and come in an assortment of colors to conform with standard codes.

Engineering News Roundup



NUCLEAR BOMB CARRIER is the F-105 Thunderchief recently selected by the Air Force for volume production. The new fighter-bomber, made by Republic Aviation Corp., is powered by the Pratt and Whitney J-75 engine; flew faster than sound on its first test flight. Design features are the long, cylindrical fuselage; short, very thin swept-back wings; needle nose and ventral fin below conventional tail surfaces.

(Continued from Page 31)

oped for use in printed circuits. Extreme flexibility, high insulation and chemical resistance are the chief properties of the laminates.

Radiation resistant insulation materials capable of withstanding continuous operating temperatures above 932 F were exhibited by the Mycalex Corp. of America. The molded ceramoplastic material, Supramica 560, remains dimensionally stable even during short-time operating temperatures of 1200 F.

Three-dimensional radar developed by Hughes Ground Systems Laboratory, provides target data from a single antenna, transmitter, and receiving channel. The electronic scan antenna causes the radiated pencil beam to scan space rapidly. This scan plus mechanical rotation of the antenna provides three-dimensional coverage.

Stardust impact could destroy the earth satillite by continued abrasion. Daystrom Laboratories has devised a compact erosion gage to measure the rate of destruction by proportionate increases in resistance of a plate between two electrodes.

Needle-like periscopes more than 15 ft long are finding uses in industry by probing internal passages of structures. Precision lenses and built-in flashlights make the borescope useful in hard-to-get-at places. It saves disassembly of parts for visible inspection. Built by National Electric Instrument Co., the borescope operates on house current or dry cells.

Meetings

AND EXPOSITIONS

April 30-May 1—

Metal Powder Association. 13th Annual Meeting and 1957 Metal Powder Show to be held at the Drake Hotel, Chicago. Further information is available from association headquarters, 130 W. 42nd St., New York 36, N. Y.

April 30-May 2—

Investment Casting Institute. Annual Spring Meeting to be held at the Sheraton Park Hotel, Washington, D. C. Additional information can be obtained from institute headquarters, 27 E. Monroe St., Chicago 3, Ill.

May 1-2—

National Warm Air Heating & Air Conditioning Association. Second Technical Conference to be held at the Hotel Cleveland, Cleveland. Further information is available from association headquarters, 640 Engineers Bldg., Cleveland 14, O.

May 1-3—

Electronic Components Conference to be held at the Hotel Mor-

News Roundup

rison, Chicago. Sponsors are Institute of Radio Engineers, American Institute of Electrical Engineers, and Radio-Electronics-Television Manufacturers Association. Additional information is available from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

May 1-3—

Society for Experimental Stress Analysis. 1957 Spring Meeting and Exhibit to be held at Hotel Statler, Boston. Further information can be obtained from SESA headquarters, P. O. Box 168, Cambridge 39, Mass.

May 6-10—

Industrial Tool and Production Show of Canada to be held in the Industry Bldg., Exhibition Park, Toronto. Additional information can be obtained from show headquarters, 19 Melinda St., Toronto, Ont., Canada.

May 6-10—

American Foundrymen's Society. 61st Annual Castings Congress and First Engineered Castings Show to be held at the Music Hall, Cincinnati. Further information is available from society headquarters, Golf and Wolf Roads, Des Plaines, Ill.

May 7-9—

American Institute of Electrical Engineers. East Central and Middle Eastern District Meeting and Air Transportation Conference to be held at the Dayton-Biltmore Hotel, Dayton, O. Further information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

May 13-15—

National Conference on Aeronautical Electronics to be held in Dayton, O. Sponsor is the Institute of Radio Engineers. Additional information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

May 14-16—

Second Annual Industrial Nuclear Technology Conference to be held at the Museum of Science and

(*Continued on Page* 41)

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Circle 427 on page 19→

Now's the time for a complete checkup on drafting room equipment

CHECKLIST FROM YOUR POST SUPPLIER

Frederick Post Company and your POST supplier suggest you consider improving the efficiency of your drafting operations with the equipment and supplies presented on these pages.

Adhesives
Adjustable Drawing Stands
Adjustable Drawing Tables
Adjustable Triangles
Ames Lettering Instrument
Architect's Scales
Art Gum Erasers
Attachments, Parallel Rule
Auto-Shift Tables

Basswood Boards
Beam Compasses
Big Bow Compasses
Blockout Ink
Blutex Tracing Vellum
Blue Print Marking Pencils
Board Cover
Board, Illustration
Boardmaster Drafting Machine
Boards, Drawing
Boards, Cutting
Bow Instruments
Braddock Lettering Angles
Bristol Board
Brushes, Dusting

Cabinets, Filing
Cartridge Stabilizers
Cement, Best-Test Rubber
Chairs, Draftsmen
Charcoal Paper
Circular Curves
Circular Slide Rules
Cleaning Pads
Cleaning Powder
Cloth, Cross Section
Cloth, Tracing
Colored Ink
Colored Pencils
Combination Curves
Compass Leads
Compasses

More drafting efficiency check points on following pages.

FROM YOUR POST SUPPLIER

Here are some major checkup points

Compensating Planimeters
Contour Pen
Coordinate Paper
Copenhagen Ship Curves
Corrector Fluids
Covers, Drawing Boards
Cross Section Cloth
Cross Section Pads and Papers
Crow Quill Pens
Curve Rulers, Adjustable
Curves, Circular
Curves, Irregular
Cutters, Paper

Dazor Lamps
Detail Papers
Detail Ruling Pens
Dividers
Drafting Machines
Drafting Tape
Drawing Boards
Drawing Board Covers
Drawing Inks
Drawing Instrument Sets
Drawing Paper
Drawing Tables
Drop Bow Compasses
Dust Covers
Dusting Brushes

Electric Erasing Machine
Ellipses, Templates
Engineer's Scales
Erasers
Erasing Fluids
Erasing Shields

Federal Aid Sheets
Filing Cabinets
Film, Tracing
Fluorescent Tracing Tables
Folding Parallel Rules
Folding Rules
French Curves

Graph Papers

Hamilton Tables
Hand Levels
Hexo Erasers

Illuminated Tracing Tables
Illustration Boards
Imperial Tracing Cloth
India Ink
Ink Tracing Cloth
Irregular Curves
Isometric Sketching Papers

Jack Knife Ruling Pens

Krylon Plastic Spray

Lamps, Drafting
Lead Holders
Lead Pencils
Lead Pencil Pointers
Lettering Angles
Lettering Guides
Lettering Pens
Liquid Eraser
Logarithmic Papers

Take a good look at your present files

Investigate Hamilton's UNITSYSTEM and see how it provides easy accessibility for desired tracings, yet assures complete protection against wear and tear. These sturdy, interchangeable steel units save valuable space and permit extra capacity. Tracings are safely stored in interlocking filing systems for various classifications of drawings.

In the Shallow-Drawer unit, drawings are easier to find, remove and refile, due to Hamilton's exclusive tracing lifter device. Every tracing is immediately accessible and cannot be damaged in handling.

For easier drawing and sharper prints test these POST tracing mediums

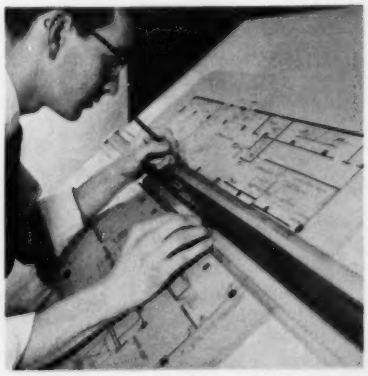
Compare your tracing mediums with the three most popular of POST'S many papers and cloths. In addition to easier drawing and sharper prints, POST'S production techniques provide the extra long life often needed for permanent record drawings.

BLUTEX tracing vellum is transparentized under an improved process that permits fast, clean erasures without ghosting . . . *even after repeated reproduction and aging.*

WHITEX is a durable tracing cloth with surface texture specially perfected to produce dense pencil lines that reproduce like ink. Moisture-resistant and highly transparent.

PENCILTEX has all WHITEX features, with blue tint.

Check into latest developments in parallel ruling

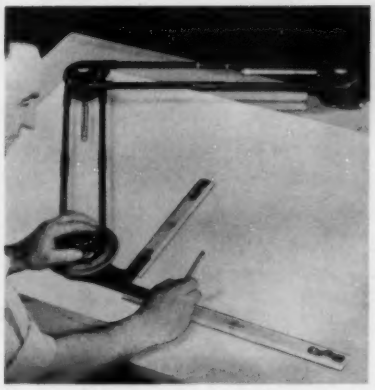


See for yourself how new design modifications in POST'S No. 1704 PARALLEL RULING UNIT now assure smoothest operation, precision performance. Cords attach at top and bottom of board . . . run through a channel mounted on straight edge. New all-nylon pulleys respond to finger-tip control, eliminate binding. Low, neat mahogany pencil ledge is integral part of straight edge. Precision-finished transparent beveled edges are clear, durable optical plastic.

The POST PARALLEL RULING UNIT *stays parallel* when working *in any section of any sized board.*

...increase productivity... ...raise morale...improve efficiency

Examine BOARDMASTERS for good investments in faster, lower cost drafting



Now is a good time to double-check to see if *your* drafting facilities are keeping pace with up-to-date developments. See for yourself how Universal BOARDMASTER drafting machines provide greater drafting efficiency and productivity. No other drafting machines can match their precision and easy operation. Here are 3 of the ten exclusive BOARDMASTER features that enable draftsmen to do a better job, faster: • Unlimited Protractor Visibility • Ball Bearing Indexing • Positive Baseline Control.

Investigate extra efficiency and space saving Hamilton AUTO-SHIFT tables

Here's why the man at the AUTO-SHIFT produces more and occupies less space. Feather-touch controls make it easy to adjust board slope and height for quick, convenient change of board position, reducing waste motion and fatigue. Draftsman works at any section of his board without leaving his chair. All reference space and drawers are within a chair's turn from the table, in least possible floor space. Work is shifted to the draftsman—the draftsman never reaches far for work. Ample drawers and files solve the storage problem.

New, modern Hamilton furniture will quickly change the looks and efficiency of any drafting room!

Don't overlook special pads that make sketching to scale faster

Here's a tip about two unique POST pads developed to step-up production and cut down waste motion.

The TRI-POST pad is actually a single sketch pad combined with *six* different scale combinations. All that is necessary to sketch to scale is a flip of a page to bring the right choice of grid scales into position under a sheet of top-grade, transparent paper. POST's No. 370 pad is a good shortcut in sketching quickly to scale.

PHANTOM RULED pads give all the drafting advantages of grid-lined paper without sacrificing excellent reproduction. Lightly-ruled lines will not reproduce when drawing is printed. POST No. 375 pads are available in a variety of rulings and different size sheets.

Magnifiers For Slide Rules
Magnifying Glasses
Map Measures
Mapping Pens
Marking Pens
Mechanical Pencils
Mending Tape
Metal Filing Cabinets
Midget Bow Compasses
Mounting Tape

Oil Stones
Ott Planimeters
Ovaloid Tracing Paper

Pads, Sketching
Pads, Tracing Paper
Pantographs
Papers, Drawing
Papers, Tracing
Parallel Rules
Parallel Ruling Attachments
Pasteboard Tubes
Patent Office Bristol Board
Penciltex Cloth
Pencil Cloth
Pencil Erasers
Pencil Holders
Pencil Pointers
Pencil Sharpeners
Pencil Tracing Cloth
Pencils
Pen Holders
Pen Points
Pens
Pens, Ruling
Phanton Ruled Pads
Pink Pearl Erasers
Plan-Profile Cloths and Papers
Planimeters
Plastic Spray
Pocket Scales
Pocket Slide Rules
Pocket Tapes
Polar Co-Ordinate Paper
Polar Planimeters
Powder, Tracing Cloth
Profile Cloths and Papers
Proportional Dividers
Protractors
PTM Tracing Paper

Quadrille Ruled Cross-Section Paper

Railroad Curves
Railroad Pens
Rapidograph Pen
Reducing Glasses
Reproduction Machines
Roll Tracing Files
Rubber Cement
Ruling Pens

Scales
Scale Protractors
Scribers
Sharpeners, Pencil
Sharpening Stones
Shears
Ship Curves
Sketch Pads
Sketching Paper
Slide Rules
Speed Ball Pens
Steel Arm Protractors
Steel Filing Cabinets
Steel Straight Edges
Steel T Squares
Stools
Straight Edge Attachments

Turn page for more suggestions that will help you improve drafting output.

FROM YOUR

POST

SUPPLIER

After your checkup

consult your POST supplier to plan greater drafting room efficiency

Straight Edges
Strathmore Board
Studio Bristol Board

Tables
Table Tops
Tack Lifters
Tank Pens
Tape, Drafting
Tapes, Measuring
T-Squares
Templates
Tracing Cloths
Tracing Cloth Cleaner
Tracing Cloth Powder
Tracing Files
Tracing Folders
Tracing Papers
Tracing Paper Pads
Tracing Vellums
Transparent Protractors
Triangles, Adjustable
Triangles, Transparent
Trimming Boards
Trimming Shears
Tri-Post Pad
Trupoint Lead Pointer

Universal Drafting Machines

Vellums
Versalog Slide Rules
Vertical Filing Cases
Vinylite Eraser

Water Color Board
Waterproof Drawing Inks
Whitex Cloth
Wood Trestles
Wrico Lettering Guides
Wrico Lettering Pens

Zephyr Lettering Set

Efficient service by locally-owned, competent suppliers is the cornerstone of POST's dealer network. Each supplier is a specialist in equipping and supplying drafting rooms. His experience comes from helping to solve countless drafting room problems right in your own area. His specialized activities range all the way from planning a reorganization of filing space to procuring that hard-to-locate template you may be searching for.

Make a thorough drafting room checkup and then consult your POST supplier, for still more ways to boost productivity. Have him stop in for a visit soon. Put his ideas to work to improve drafting room efficiency.

Review the checklist from A to Z and determine items about which you want specific information. Whether it's a major review of your equipment or merely some routine supplies, your POST supplier will be pleased to work closely with you.

FREDERICK POST COMPANY

3650 N. AVONDALE AVENUE, CHICAGO 18, ILLINOIS

Yes, we've reviewed your Drafting Equipment and Supplies checklist. Furnish us with information and prices on the following:

Featured Products

- ☐ Hamilton Unit Files
- ☐ Blutex Tracing Vellums
- ☐ Penciltex & Whitex Tracing Cloths
- ☐ Parallel Ruling Attachments
- ☐ Boardmaster Drafting Machines
- ☐ Hamilton Auto-Shift Tables
- ☐ Special Sketch Pads
- ☐ Send Equipment & Supply Catalog

List Other Products Here:

_____
_____
_____
_____
_____
_____
_____
_____

Name _____ Title _____

Company Name _____

Company Address _____

City _____ Zone _____ State _____

Here's your free, reference catalog for drafting room needs.

(*Continued from Page* 36)

Industry, Chicago. More information can be obtained from Dr. Leonard Reiffel, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

May 15-17—

Radio - Electronics - Television Manufacturers Association. Annual Meeting to be held at the Sheraton Hotel, Chicago. Additional information is available from association headquarters, 1721 De Sales St. N. W., Washington 6, D. C.

May 16-18—

Society of Naval Architects and Marine Engineers. Annual Spring Meeting to be held at the Lafayette Hotel, Long Beach, Calif. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

May 19-23—

American Society of Mechanical Engineers. Oil and Gas Power Conference to be held at the Kentucky Hotel, Louisville. Additional information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

May 20-21—

Eighth Annual Appliance Technical Conference to be held in the Engineering Societies Bldg., Detroit. Conference is sponsored by the Subcommittee on Domestic Appliances of the American Institute of Electrical Engineers. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

May 20-23—

Design Engineering Show to be held at the Coliseum, New York. Second Annual Design Conference, to be held in conjunction with the show, is sponsored by the Machine Design Div. of ASME. Further information on the show is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

May 22-23—

American Iron and Steel Institute. Annual Meeting to be held

(*Continued on Page* 44)

Now! When You The Greatest Tracing

Prove it to Yourself!

Use the special trial offer above to make your tests of all-new Bruning "Visi-Vel" Tracing Paper

Greater Translucency!

Compare it with any paper you are now using. Extensive tests have shown "Visi-Vel" to be at least 5% more transparent than competitive papers. And it retains its transparency—it will not leach, age, or discolor.

Cleaner, Safer Erasures!

Erase and re-erase to your heart's content and see how "Visi-Vel's" durable surface gives you *clean* erasures without damage. Find how beautifully "Visi-Vel" takes pencil hardnesses up to 9H without ever tearing or puncturing.

Faster Reproduction!

Discover for yourself how "Visi-Vel" helps you make sharper, cleaner prints in record time. And you can count on getting the same reproduction results from the same drawings months from now. Tests show that "Visi-Vel" boosts print production as much as 25% over other leading transparentized papers.

Need It Most.. Paper Ever!

New Bruning

"VISI-VEL"

Resin-Transparentized

TRACING PAPER!

Highest Reproduction Speed

Greatest Over-all Strength

Best All-around Workability

Never before has a tracing paper offered you so much to speed both drawing and reproduction, to raise the quality of your drawings and prints! Never has a drawing medium been needed so much to help meet the growing demands of a tremendous production boom!

All-new "Visi-Vel" offers the highest reproduction speed, the greatest over-all strength, and the best all-around workability of any tracing paper on the market today! Yet, it costs no more than other resin-transparentized papers.

Best for Drawing! "Visi-Vel" helps you make cleaner, neater drawings and tracings—easier and faster! Because of its exceptional strength and workability, it withstands heavy handling . . . takes erasures beautifully without damage . . . resists ghosting . . . accepts pencil hardnesses up to 9H without tearing or puncturing. A perfect balance of opacity and transparency makes it ideal for either drawing or tracing.

Best for Reproduction! By test, "Visi-Vel" boosts print production as much as 25% over other transparentized papers. Its superior inert resin transparentizer provides unsurpassed reproduction translucency that's uniform and permanent.

Best for Filing! Your drawings on "Visi-Vel" can be filed indefinitely without deterioration of the drawing, the workability of the paper, or its reproduction quality. Containing no oily substances, the transparentizer will not transfer to other sheets in your file.

You can obtain "Visi-Vel" in three different weights (thin, medium, and heavy), and in rolls or sheets. But right now, why not start with the generous trial offer of the 5-yard roll for only $1.00 or send for a free 8½" x 11" sheet. Prove to yourself the dramatic advantages of all-new "Visi-Vel!"

BRUNING

America's Leading Supplier of Engineering and Drafting Equipment

Offices in 37 Cities of the U. S. and Canada

CHARLES BRUNING COMPANY, INC., CHICAGO

In Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto 1, Ont.

Charles Bruning Company, Inc., Dept. 44-K
4700 Montrose Avenue, Chicago 41, Illinois

☐ Enclosed find $1.00. Please send me 5-yard, 36-inch roll of all-new "Visi-Vel" tracing paper at no further cost to me.

☐ Please send me free 8½ x 11-inch trial sheet of No. 340M "Visi-Vel".

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

News Roundup

(*Continued from Page* 41)

at the Waldorf-Astoria Hotel, New York. Additional information can be obtained from institute headquarters, 350 Fifth Ave., New York 1, N. Y.

May 22-24—

American Society for Quality Control. 11th Annual Convention to be held in the Masonic Temple, Detroit. Further information is available from R. V. Ward, Canadian Industries Ltd., P. O. Box 10, Montreal, P. Q., Canada.

June 2-7—

Society of Automotive Engineers. Summer Meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

June 3-5—

American Society of Refrigerating Engineers. 53rd Annual Meeting to be held at Hotel Fontainbleau, Miami Beach, Fla. Additional information can be obtained from society headquarters, 234 Fifth Ave., New York 1, N. Y.

June 9-13—

American Society of Mechanical Engineers. Semiannual Meeting to be held at the Sheraton-Palace Hotel, San Francisco. Further information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

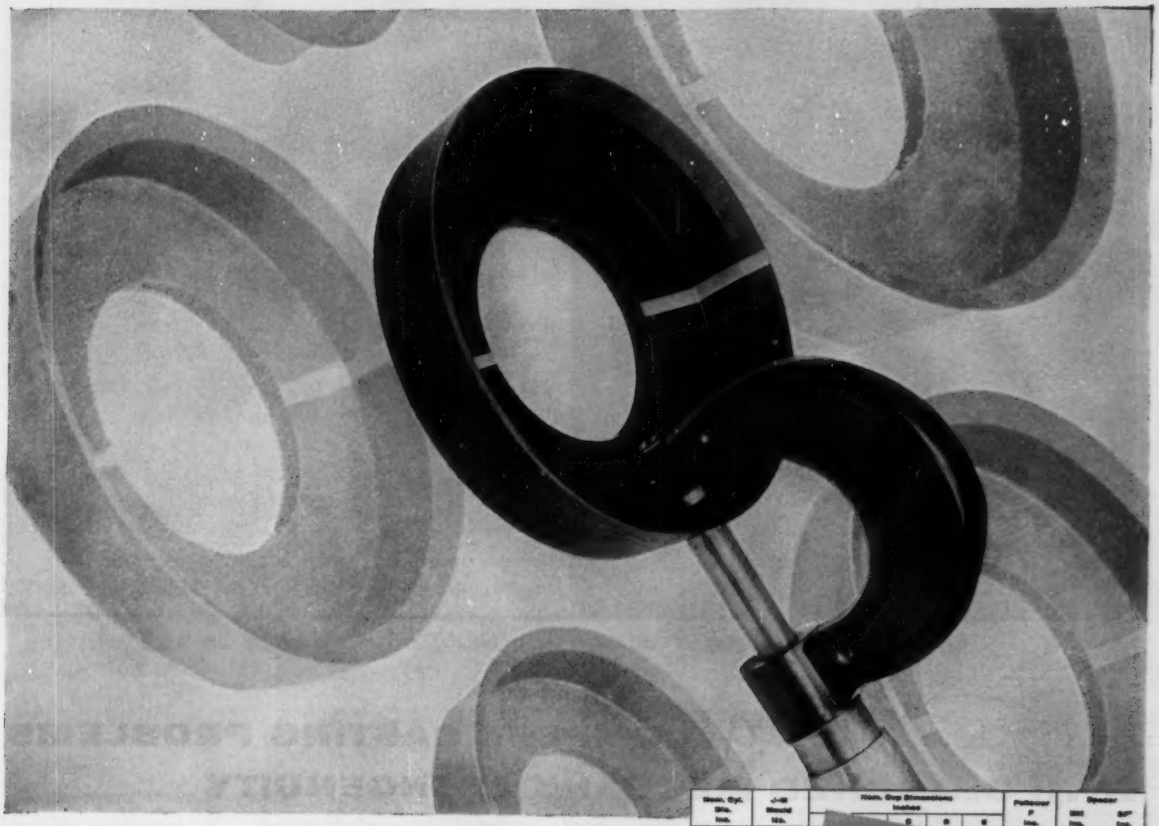
June 11-13—

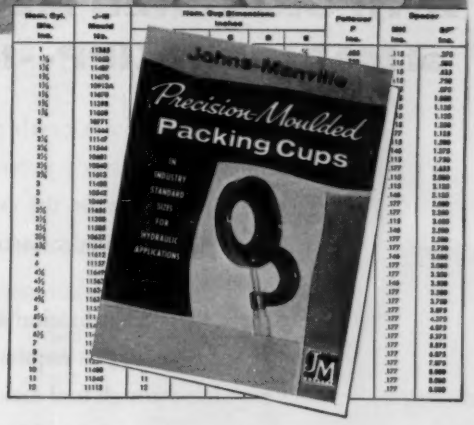
Third Western Plant Maintenance and Engineering Show and Conference to be held at the Civic Auditorium, San Francisco. Additional information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Oct. 14-15 —

Fourth Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsors are the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information can be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Packing Cups in Industry Standard Sizes Precision-moulded by Johns-Manville





Ask for new size list and compound color code of these J-M Packing Cups

Made in the original *square heel* design, developed and perfected by Johns-Manville, these cups are precision made to assure maximum efficiency.

They are available in a variety of styles and compounds to suit most pressures, temperatures and fluids. For easy identification, cups are marked with a different color stripe for each compound.

Complete dimensions, compounds, code and piston design data are in folder PK-107A. Write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ont.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville PACKINGS, GASKETS and TEXTILES

Circle 431 on page 19

Diluting COMPLEX CASTING PROBLEMS WITH SEASONED MECHANICAL INGENUITY at MADISON-KIPP--for zinc and aluminum castings

One complex die casting often highlights the industry's potential for other uses. This may be the case with the Ohio Chemical Inhaler Casting here illustrated.

For full process utilization seasoned mechanical ingenuity is required, from die designing through tool making and on to the final dependable production.

The skilled mechanics at Madison-Kipp have been helpful to highly placed designers and engineers for over a quarter century. They may be able to assist you.

Please clip this ad as a reminder to contact us when you have die casting requirements.

kipp

MADISON-KIPP CORPORATION

210 WAUBESA STREET • MADISON 10, WISCONSIN, U.S.A.

Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

Circle 432 on page 19

How to calculate the efficiency of worm gearing

The efficiency of worm gearing is determined by frictional losses at the tooth contact, bearings and oil seals plus losses from oil churning and windage. A formula for efficiency at the tooth contact may be developed from a consideration of the forces at the contact. Figure 1 shows these forces acting on a developed section of the worm thread. For simplicity the pressure angle has been assumed to be zero.

The coefficient of friction of the worm and gear is a function of the materials, finish, lubrication and rubbing speed. The latter is the relative speed between a point on the pitch surface of the gear and one on the pitch surface of the worm. The coefficient of friction varies very little at high rubbing speeds but rises with increasing rapidity as the speed drops below 500 fpm.

The efficiency formula developed in Figure 1 involves worm lead angle and the friction angle. Figure 2 provides a relationship between friction angle and rubbing speed based on tests made on accurately manufactured gearing consisting of hardened and ground worm and bronze gear operating in oil.

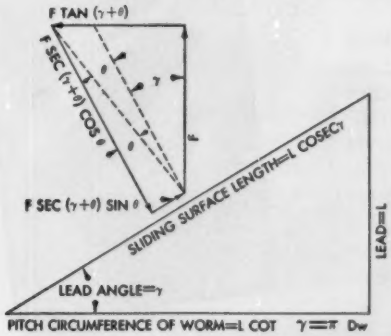
The formula for rubbing speed is:

$$V = \frac{.262\ Dw \times \eta}{\cos \gamma}$$

where

V = Rubbing speed – feet per minute
Dw = Worm pitch diameter – inches
η = Worm speed – rpm
γ = Worm lead angle

FIGURE 1.
Development of equation for efficiency at contact between worm and gear



F=TANGENTIAL FORCE ACTING ON GEAR

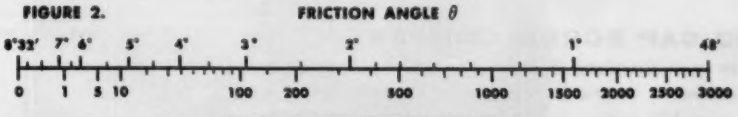
F TAN $(\gamma + \theta)$ = TANGENTIAL FORCE APPLIED TO WORM

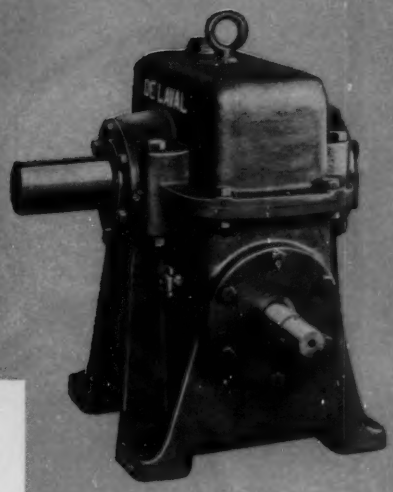
F SEC $(\gamma + \theta)$ COS θ = FORCE NORMAL TO CONTACT SURFACE

F SEC $(\gamma + \theta)$ SIN θ = FRICTIONAL FORCE

$$\text{EFFICIENCY} = \frac{\text{WORK REALIZED}}{\text{WORK APPLIED}} = \frac{L \times F}{L \cot \gamma \times F \tan (\gamma+\theta)} = \frac{\tan \gamma}{\tan (\gamma+\theta)}$$

FIGURE 2.





DE LAVAL Worm Gear Speed Reducers Offer Efficiencies to 96%

Ruggedly built for long efficient service De Laval speed reducers are made in horizontal and vertical single reduction units in ratios of 3:1 to 100:1. They are also available in double horizontal and vertical double reduction units as well as in helical-worm and double-worm design. Ratios from 37.8:1 up to 6400:1.

Write for your copies of Catalogs G-WBV and G-WWH to De Laval Steam Turbine Company, 858 Nottingham Way, Trenton 2, New Jersey

BRUTE STRENGTH FOR BIG ASSEMBLIES—

Cleveland large diameter upset forged socket head cap screws

On big presses, extrusion machinery, and earth moving equipment, fasteners not only have to support massive static loads; they must also withstand the dynamic stress of heavy impact, shock and vibration.

Engineered specifically for this type of service, Cleveland large diameter socket head cap screws are upset forged from specially heat-treated alloy steel. The forging process shapes the steel so that grain flow follows the contour of the head; eliminates planes of weakness along which shear might occur under dynamic stress; and protects assemblies against fastener fatigue failure.

In large diameters we regularly stock 1¼-7 and 1½-6 through 12 in. for same-day shipment. For other standard sizes from 1⅛ to 3 in. diameter through 12 in. length, we have the stock and the tooling to produce your order quickly.* For prompt service, contact your local Cleveland distributor. He can also supply large diameter upset forged hexagon head cap screws.

*Diameters over 3 in., lengths over 12 in., available on special order.

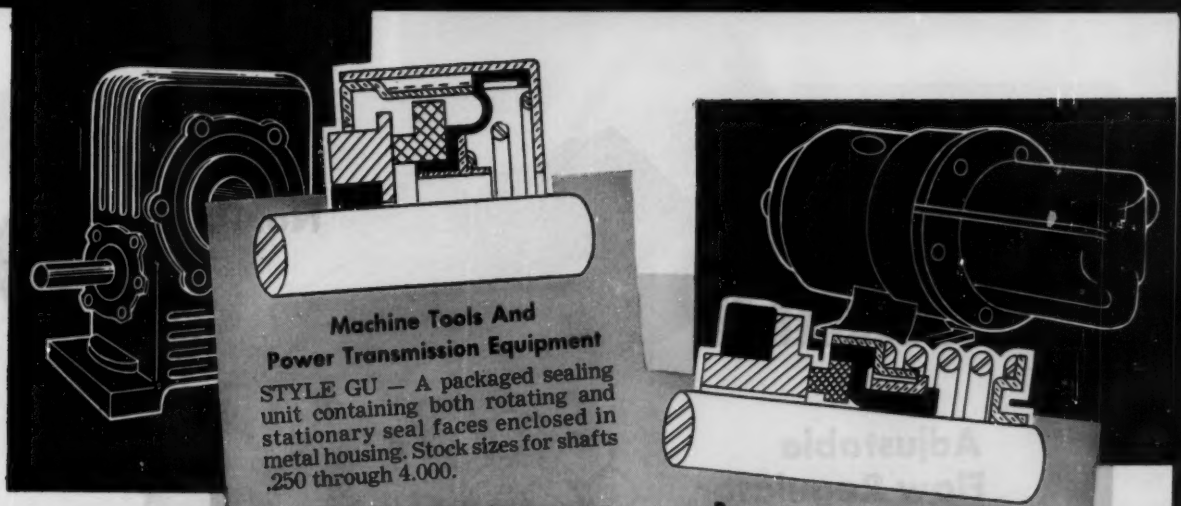
New folder gives dimensions (including old and new head details), physical properties, weights, prices of Cleveland large diameter socket head cap screws. Write for copy today.

THE CLEVELAND CAP SCREW COMPANY

4444-6 Lee Road, Cleveland 28, Ohio

WAREHOUSES: Chicago • Philadelphia • New York • Providence • Los Angeles

Circle 433 on page 19



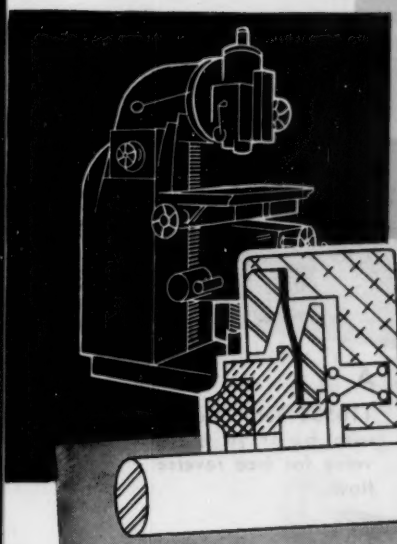
Machine Tools And Power Transmission Equipment

STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.

Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

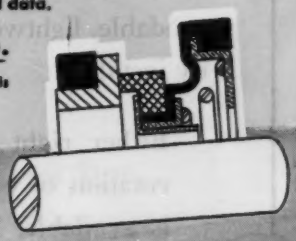
A Complete Line GITS SHAFT SEALS For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

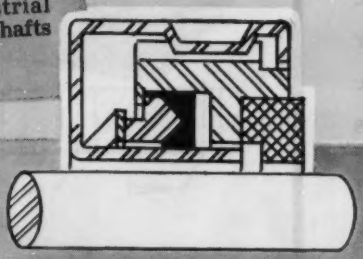
1868-A South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



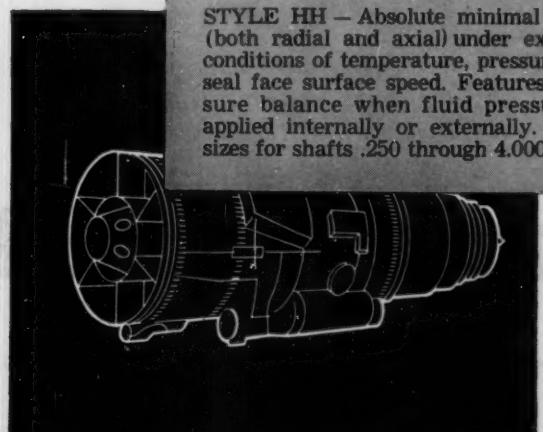
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



Circle 434 on page 19

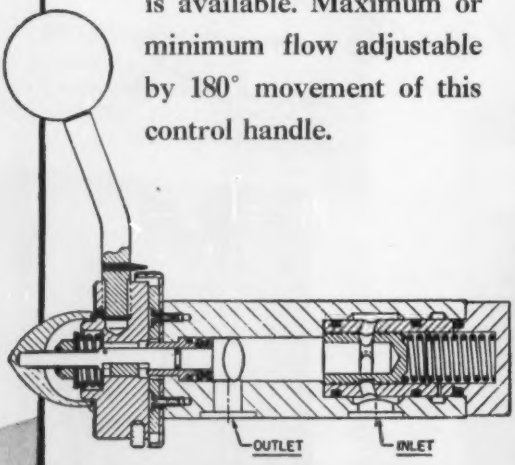
Another WATERMAN WINNER

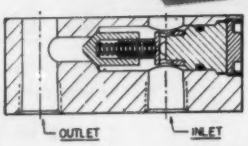
Adjustable Flow Regulator

An adjustable flow regulator adapted for manifold mounting. Sub-plate kits are furnished with built-in check valves for free reverse flow.

They are interchangeable, dependable, lightweight and easily installed.

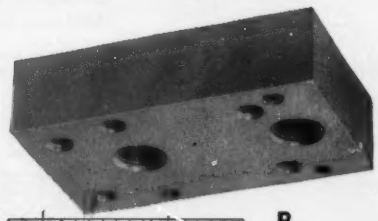
Either right or left hand rotation of control handle is available. Maximum or minimum flow adjustable by 180° movement of this control handle.





A

110534 Sub-Plate Kit with built-in check valve for free reverse flow.



B

110516 Sub-Plate Kit.

Write for illustrated bulletin F describing the many valuable features of this Adjustable Flow Regulator.

WATERMAN ENGINEERING COMPANY

725 CUSTER AVENUE • EVANSTON, ILLINOIS

NOTHING *can equal Stainless Steel*

in its unique combination of properties

No other design material can match Stainless Steel in its unique combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. If you're looking for a reliable source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.

UNITED STATES STEEL CORPORATION, PITTSBURGH
AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

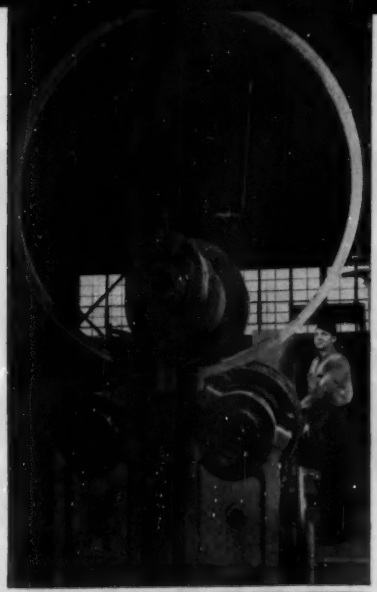
USS STAINLESS STEEL

SHEETS • STRIP • PLATES • BARS • BILLETS
PIPE • TUBES • WIRE • SPECIAL SECTIONS

UNITED STATES STEEL

USS

Circle 436 on page 19



For Formability...

Jet engine and pressure vessel makers are using roll-formed rings in large numbers these days. Alloy Manufacturing Company in Pittsburgh is a major supplier of Stainless Steel fabricated parts, and they process this steel on ordinary "carbon steel rated" equipment without difficulty.

For Cleanliness...

Bates Manufacturing Company, Lewiston, Maine, is a famous name in cotton goods. They used to have trouble with dyeing equipment; the iron vats held the old colors and "killed" new colors. With Stainless Steel dye kettles, old colors actually *rinse* out, without costly scrubbing.

For Style...

G & G Woodcraft, Dinette Division, in Detroit, is selling a handsome new dinette table, designed by Gelitis, with a polished Stainless Steel top. The top is backed with plywood, and there is no metallic sound when it is struck. Stainless is a perfect material for contemporary design, and it's so *practical*.

Circle 435 on page 19

Attend the 1957 DESIGN ENGINEERING SHOW and Conference

THE ORIGINAL EQUIPMENT MARKET EXPOSITION

New York Coliseum
May 20-23, 1957

Here are some of the products you'll see at the show:

Electrical Components
such as actuators, connectors, dynamotors, generators, insulators, meters, motors, switches and relays, rectifiers, solenoids, thermostats, wire and components, thermocouples, strain gages, timing motors, etc.

Mechanical Components
such as axles, bearings, clutches, conveyors, drives, governors, mountings, couplings, speed reducers, timers, wheels, vibration mountings, springs, gears, belts and chains, lubricating equipment, etc.

Engineering Materials (metallic and non-metallic)
such as aluminum alloys, clad metals, beryllium alloys, gray iron, high alloy steels, metal powders, titanium, magnesium, bearing alloys, nickel alloys, etc.; carbon, ceramics, cork, glass, jewels, paper, plastics, silicones, rubber, wood, graphite, etc.

Fasteners
such as adhesives, clips, nuts, retaining rings, rivets, welding, etc.

Finishes and Coatings
such as anodized finishes, chemical colorings, lacquers, paints and varnishes, plated coatings, etc.

Hydraulic and Pneumatic Components
such as accumulators, boosters, controls, pumps, cylinders, hose and tubing, piping, valves, etc.

Shapes and Forms
such as die castings, drop forgings, formed nonmetallics, perforated materials, press forgings, sand castings, tubing, etc.

Accessories
such as computers, drafting instruments; machines, supplies, recorders, reproduction equipment, supersonic generators, transducers, etc.

- Over 350 manufacturers exhibiting on 3 big floors.
- Thousands of products to help you do a better design job and reduce manufacturing costs.
- See for yourself... pick things up... bend them... action is the working atmosphere of this great show.
- Compare one product with another, on-the-spot, to aid your design decisions.
- Talk to technical experts who can read your blueprints.
- Save time at the important job of finding what you need.
- Take home literature and test samples for solving future problems.

Send for these Registration Cards — today!

Make sure you don't miss out on this great design engineering event. Write immediately for your rapid registration cards, requesting as many as you need for yourself and colleagues.

Address your request to:

CLAPP & POLIAK, INC.
Management
DESIGN ENGINEERING SHOW
341 Madison Avenue
New York 17, New York

Attend the Design Engineering Conference

Sponsored by the Machine Design Division
American Society of Mechanical Engineers

Concurrent with the show . . . in the New York Coliseum . . . the outstanding Design Engineering Conference will approach design problems from a practical, down-to-earth level. Editors of the four leading design publications will serve as chairmen in sessions devoted to the three major design fields: Mechanical, Materials, and Electrical. We urge you to write for application forms to the Conference.

CLAPP & POLIAK, INC.
Management
DESIGN ENGINEERING SHOW
341 Madison Avenue
New York 17, New York
MUrray Hill 4-3432

Circle 437 on page 19

HYDRAULICS in AUTOMATION

No place for down-time

that's why **CROSS** specifies HYDRALUSTER tubing exclusively!

Hydraluster tubing is carrying the vital load of hydraulic transmission in this 350 ft. Cross transfer machine. Hydraluster is there because *every* part and assembly has to be 100 per cent dependable. There is too much at stake for anything less.

Why does Hydraluster get the call? . . . because it is a revolutionary improvement over any previous type of hydraulic tubing. *Inside*, Hydraluster has a new type of tubing surface, very much like a gun barrel. This smoothness cuts friction and heat, and the result is higher power efficiency and lower reaction times. This new surface is also highly resistant to oxidation and scale . . . added protection for valves, pumps and meters.

Here we quote Mr. Ralph E. Cross, Executive Vice President of The Cross Company. "*We've used Summerill Tubing for years because we felt it was the best. And when Summerill topped even their best with Hydraluster, it was only logical that we go along with the improvement.*"

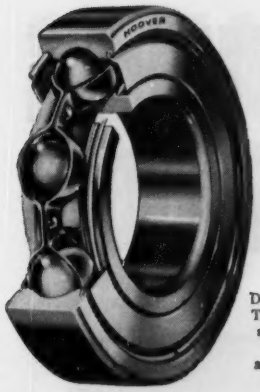
*Stations—104. Operations—265 drilling, 6 milling, 21 boring, 56 reaming, 101 countersinking, 106 tapping, and 133 inspection.

SAMPLES and SPECIFICATIONS: Examine Hydraluster right at your desk or board. Your name on company stationery will bring samples and specifications.

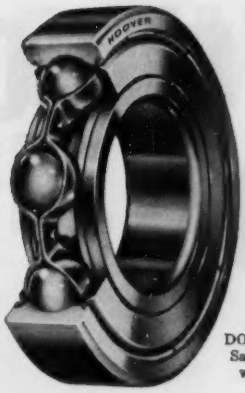
Summerill **Tubing Company Division-Columbia Steel & Shafting Co.**

PITTSBURGH 30, PA. DEPT. NO. 4-12

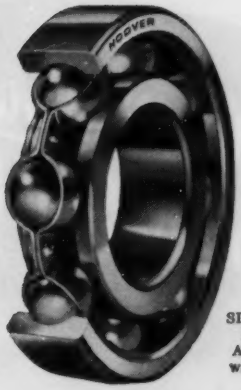
District Offices: Buffalo • Chattanooga • Chicago • Cleveland
Dayton • Hartford • Los Angeles • Philadelphia • Pittsburgh • Milwaukee • San Francisco



DOUBLE SEAL—
Teflon contact seal shown. Available with snap ring and with single or double seal.

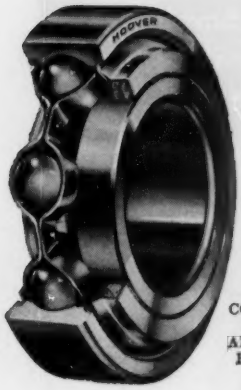


DOUBLE SHIELD—
Same sizes available with single shield.

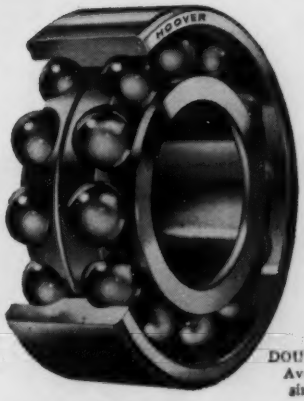


SINGLE ROW RADIAL—
Also available with snap ring.

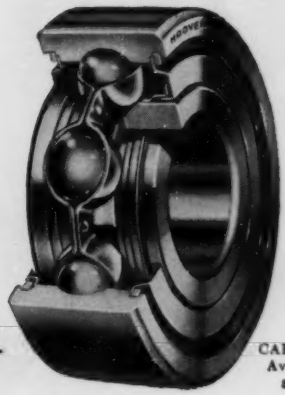
when you want quality



COMBINATION FELT SEAL AND SHIELD—
Either standard or wide outer ring.



DOUBLE ROW—
Available with single shield.



CARTRIDGE—
Available with snap ring.

you want hoover

When you want *quality* bearings to add to the performance, long life and smooth operation of your products, you want Hoover Ball Bearings.

Hoover Ball Bearings combine the exactness of *Micro-Velvet* Lapped Balls with the smoothness of *Hoover Honed* Raceways. The result . . . top quality bearings that assure unexcelled performance —quietness—long life—and heavy load capacity.

Investigate Hoover's line of ball bearings in the light, medium and heavy series. Their microscopic precision adds up to your best buy in ball bearings. Manufacturers are invited to call in Hoover engineers for technical assistance. Write for information.

Micro-Velvet and *Hoover Honed* are Hoover Trademarks.

HOOVER BALL AND BEARING COMPANY, ANN ARBOR, MICHIGAN

Send information about

- ☐ Single Row Radial Bearings
- ☐ Bearings with Shields
- ☐ Bearings with Seals
- ☐ Combination Shield and Seal
- ☐ Cartridge Bearings
- ☐ Double Row Bearings

Hoover Ball and Bearing Company, Ann Arbor, Mich.

Please send information checked. Mail copy of "Hoover Handi-Book of Anti-Friction Bearings."

Name_____

Title_____

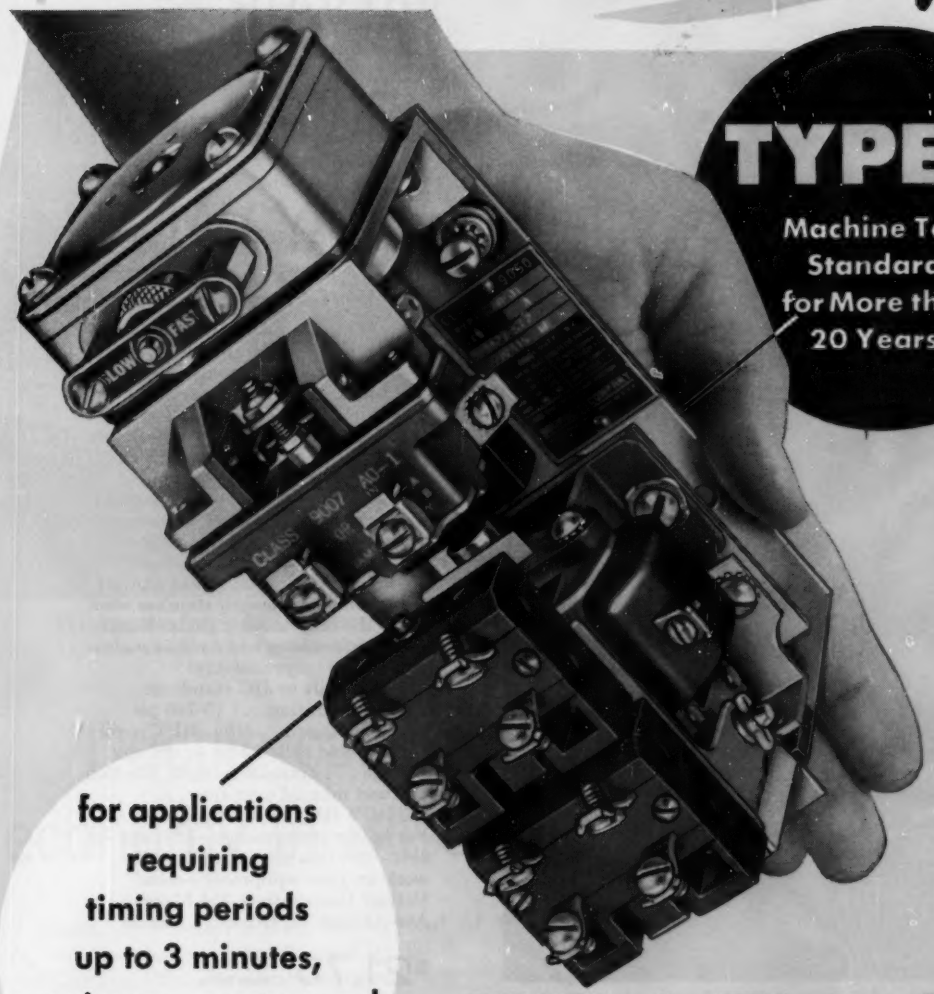
Company_____

Address_____

City_____ State_____

10

SQUARE D TIMERS YOUR JOB ... *Exactly!*



TYPE B

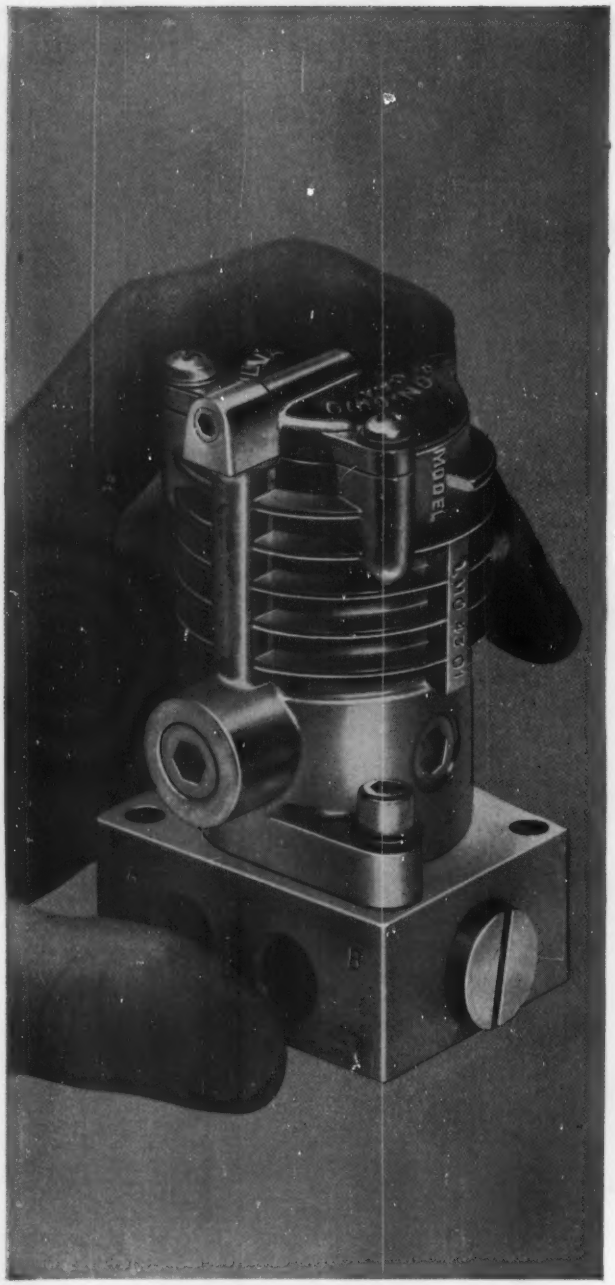
Machine Tool Standard for More than 20 Years!

for applications requiring timing periods up to 3 minutes, maximum accuracy and 1 or 2 instantaneous interlocks

COMPARISON	TYPE A	TYPE B
Timing Period	.2 to 1 min.	.2 to 3 min.
Accuracy	±15%	±10%
Interlocks	None	Max. 2 Double Circuit
Panel Space	2⅜" x 4"	2½" x 7⅛"
Convertible Delay-On • Delay-Off	Yes	Yes
Maximum Voltage, AC-DC	600 V. AC only	600 V. AC • 250 V. DC

Everybody's Ahead with Square D!

Circle 440 on page 19



something to crow about . . .

VALVAIR'S NEW BANTAM 4-WAY VALVE!

compact . . . versatile . . . economical . . .

Here it is . . . the miniaturized 4-way valve you've needed for control of small double-acting cylinders and similar devices!

Valvair's BANTAM is remarkably compact . . . a mere 4 inches high . . . 30 ounces light! And, it's lightning fast, too. Valvair ingenuity provides 4-way action with a standard Speed King pilot and a pressure-balanced shuttle in the anodized aluminum lower body. Pilot plunger, spring and shuttle—all stainless steel—are the only moving parts. Here's both performance and *built-in multi-million cycle dependability!*

Pilots built to JIC standards . . . 2 point mounting . . . 15-140 psi pressure range . . . ¼ in. NPT ports . . . solenoid coils for ac or dc, any voltage . . . optional integral junction box and manual over-ride . . . Valvair's BANTAM offers them all! For better performance—at lower cost—put this mighty midget to work on your equipment—soon! Valvair Corporation, 454 Morgan Ave., Akron 11, Ohio. AA-6269

$21.75 list price—basic valve

Find your nearest representative in the 'Yellow Pages'

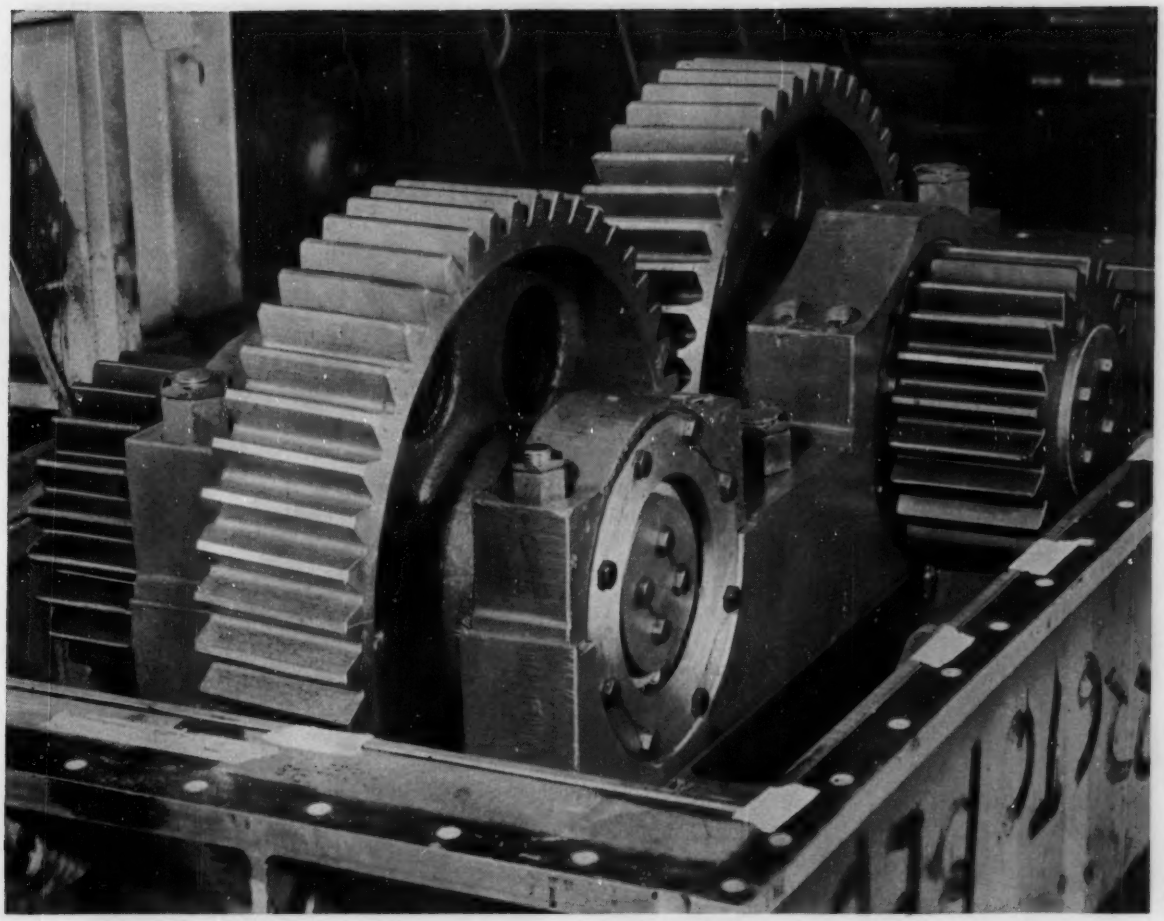
Compare . . . and you'll buy

Valvair

- **small size—4 inches high**
- **fast response—bubble-tight sealing**
- **single solenoid—only 3 moving parts**
- **corrosion-resistant materials—solenoid coil guaranteed against burn-out for life of valve**
- **pilot interchangeable with Speed Kings**
- **immediate delivery from stock**

Representatives in: Baltimore • Birmingham • Boston • Buffalo • Charleston, W. Va. • Chicago Cleveland • Cranford, N. J. • Dayton • Denver • Detroit • Eureka, Calif. • Grand Rapids Houston • Indianapolis • Kansas City, Mo. • Logansport, Ind. • Los Angeles • Louisville • Miami Milwaukee • Minneapolis • Muncie • New Orleans • New York • S. Pasadena • Philadelphia Pittsburgh • Portland, Ore. • St. Louis • Seattle • San Francisco • Syracuse • Montreal Toronto • Vancouver

Circle 441 on page 19



Bliss Specifies Ductile Cast Iron Gears for presses used to form sheet steel for the auto industry. Bliss uses ductile cast iron for at least 10 other parts in top drive presses – 16 in under drive presses.

Ductile cast iron gears prove their economy in Bliss metal-working presses

The gears, illustrated above, are typical of the many ductile cast iron gears used by E. W. Bliss Co. of Canton, Ohio, for their heavy metal-working presses.

For 30" to 108" gears, ductile iron has provided outstanding service. It gives Bliss the best combination of properties: high strength, good castability, good wear resistance and excellent machinability. All this at moderate cost.

In this gear application, 80-60-03 grade ductile provides a yield strength of 60,000 psi – more than enough to meet the stresses developed in producing 300- to 4000-ton platen loads.

These ductile iron gears – heat-treated to 208 Brinell – work well with the 8640 (Ni-Cr-Mo) pinions, assuring top-notch wear resistance. Bliss reports, *"not a single ductile iron gear replaced since ductile iron was first specified."*

Take advantage of the economy of ductile cast iron for your equipment. For many applications – cylinders, pressure vessels, pistons and the like – ductile iron outperforms conventional materials. Cuts production time. Behaves better in the shop. Saves time and money.

For complete information write for "Ductile Iron – the Cast Iron that Can Be Bent."

DUCTILE IRON

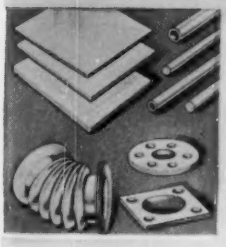
ductile iron . . . the cast iron that can be twisted and bent

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street, New York 5, N. Y.

Circle 442 on page 19

TO THE MEN WHO DESIGN AND BUILD BETTER PRODUCTS...

Heres How JOHN CRANE CAN HELP YOU!



CHEMLON PRODUCTS

"John Crane" Chemlon offers the remarkable properties of DuPont Teflon in basic forms and parts of all types for practically all applications. These range from basic forms, such as sheet, rod, tubing and tape, to machined, molded or extruded parts fabricated to specification.

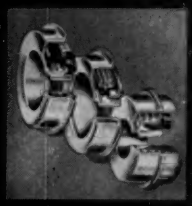
Use "John Crane" Chemlon Products for: handling all difficult acids, corrosives and solvents at temperatures from –120°F. to +500°F. . . . electronic insulation where high dielectric strength, high arc resistance and low power factor are vital . . . non-stick applications.

MECHANICAL PACKINGS

"John Crane" maintains nation-wide service and engineering to supply mechanical packings for every industrial requirement. Packings are available in all sizes, styles and materials to suit individual requirements and conditions.

Use "John Crane" Packings for: handling all types of liquids and vapors from water and steam to the most destructive acids, alkalis and solvents . . . temperatures to 1200°F. and over . . . to meet your pressure requirements.

MECHANICAL SEALS



"John Crane" engineers seals of all types and sizes for every application. Construction features include positive drive, self-alignment to compensate for normal shaft run out and precision lapped sealing faces.

Use "John Crane" Seals for: all types of rotating shaft applications such as water, steam, boiler feed water, petroleum products and hot oil, acids, corrosives and solvents . . . over a wide temperature and pressure range.

LAPMASTER Lapping Machines

Here's a machine capable of generating surface flatness to less than one light band—finishes to 2 RMS consistantly in short or high production runs . . . a machine that has given many designers an opportunity to obtain product improvement and performance at lower cost.

Use the "John Crane" Lapmaster for: precision lapping of parts for adding machines, engines, transmissions, cameras and projectors, tool and die equipment, quartz crystals, etc. . . . materials such as monel, steel, stellite, brass, aluminum, glass, carbon, plastics and ceramics.

PLASTIC LEAD SEAL* AND THRED-GARD

"John Crane"* PLS easy-to-apply plastic sealing compound provides positive protection against leakers under service applications up to 550°F., 6000 psi. It lasts for the life of the connection, yet permits easy disassembly at any time because it never hardens.

Use "John Crane" PLS for: handling water, steam, gas, petroleum products, chemicals and refrigerants...on pipe joints, threaded connections, plugs, screwed fittings, flanges and gaskets.

"John Crane" Thred-Gard high temperature compound lubricates and prevents seizing and galling of threaded surfaces and fittings under extreme heat conditions up to 1200°F. It permits connections to be drawn to a greater degree of tightness without undue strain.

Use "John Crane" Thred-Gard for: preventing damage to studs on exhaust manifolds, cylinder heads, heat exchangers, coolers, condensers . . . flange bolts on pumps, valves, autoclaves, reactors, kettles . . . die casting dies and die casting machine fittings.

GET FULL DETAILS on how John Crane can help you. Check the information you want, fill out and mail in this coupon.

- ☐ John Crane Teflon Products
- ☐ John Crane Mechanical Packings
- ☐ John Crane Mechanical Seals
- ☐ Lapmaster Lapping Machines
- ☐ John Crane PLS
- ☐ John Crane Thred-Gard

Name _____

Title _____

Company _____

Address _____

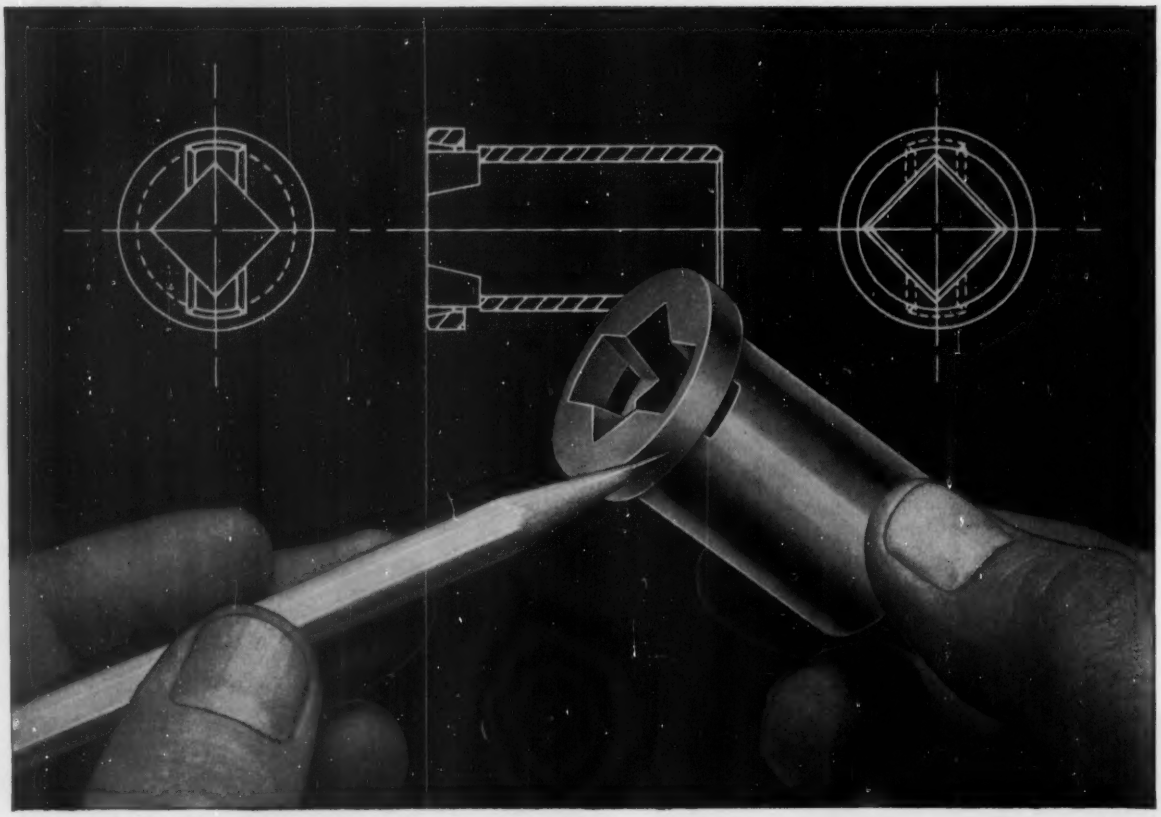
_____

Crane Packing Company, 6425 Oakton St., Morton Grove, Ill., (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

JOHN CRANE **CRANE PACKING COMPANY** 38 YEARS INDUSTRIAL PROGRESS

OFFICES IN PRINCIPAL CITIES

Circle 443 on page 19



How Would YOU Produce This Part With No Machining . . . No Scrap Metal?

PARKER SALES ENGINEERS

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CINCINNATI 14, Ohio
William H. Broxterman • 2430 Central Parkway
DETROIT 35, Mich.
Hodgson-Geisler Co. • 18917 James Couzens
GIRARD, Penna.
Daniel F. Marsh • 35 Chestnut Street
KIRKWOOD 22, Mo.
Edward F. Higgins, Jr. • 102 West Adams Street
WILTON, Conn.
Girard L. Palmer • Belden Hill Road
SYRACUSE, N. Y.
J. C. Palmer • 712 State Tower Bldg.
BELLEFONTE, Penna.
Warren G. Olson • 420 East Linn Street
LONG BEACH 11, California
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Can't be done? Parker did it . . . sharp internal corners, lateral holes, chamfers, flanged end and all . . . by fast, low-cost powdered metal pressing and sintering. No subsequent machining . . . no scrap-metal loss. Just think of the savings compared with conventional machining methods.

In addition to these inherent cost savings, Parker-engineered Powdered Metal Parts offer a wide choice of tensiles, ductility, density, impact resistance and other physicals. Tooling-up is done quickly and at relatively low cost.

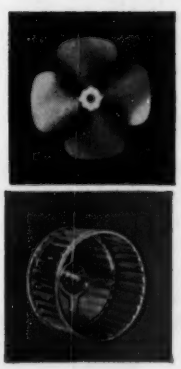
It will pay you to check on the economies and design possibilities of Parker-engineered Powdered Metal Parts. Just call the nearest sales engineer listed here or write the factory direct.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

PARKER

high pressure ALUMINUM and ZINC die castings
POWDERED METAL PARTS

Circle 444 on page 19



ALPHA TO OMEGA

In the design, development and production of the three basic lines of air impellers—fans, blower wheels and complete blower units—Torrington technology is the finest available to industry.

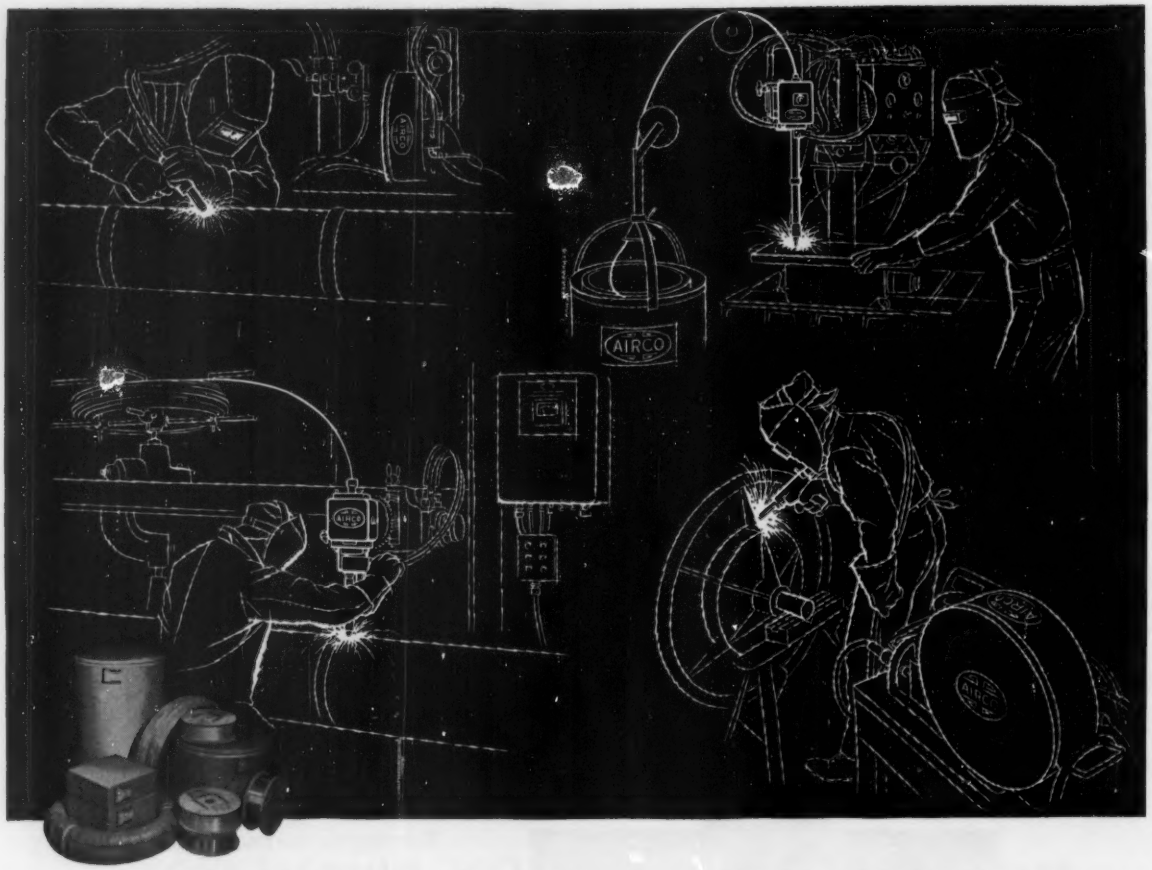
To date, more than half a million design variations of these three types of air impellers have been developed in the successful solution of industrial air moving problems.

No matter what *your* product or problem, if it involves the movement of air... *talk to Torrington!*

THE TORRINGTON MANUFACTURING COMPANY

TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • OAKVILLE, ONTARIO

Circle 445 on page 19



THE WIDEST SELECTION OF AIRCOMATIC® WIRE

for any kind of inert gas welding

Successful Aircomatic welding and Heliwelding (where filler metal is required) depend on using the correct wire. Airco can supply the widest variety of wire types and diameters — all specifically designed for use with these inert gas shielded welding processes. All Aircomatic wires meet rigidly controlled specifications as to chemical analysis, surface finish, purity, cast and packaging.

Pure . . . properly cast . . . level wound

Aircomatic Aluminum Welding Wires. New Type A finish available for all high-quality work where X-ray standards must be maintained . . . scrupulously clean . . . bright finish . . . properly wound . . . smooth surface assures trouble-free feeding.

Aircomatic Stainless Steel Welding Wires . . . excellent corrosion resistance . . . good tensile, ductility and impact properties . . . use to weld ordinary joints, apply stainless linings, build-up stainless overlays and join stainless overlays and join stainless clad materials.

Aircomatic Copper and Copper Base Alloy Welding Wires. Use to assemble copper bus bars . . . fabricate copper or bronze vats . . . build-up worn propellers, piston and valve parts . . . available in both solid and stranded types.

Aircomatic Steel Welding Wires. Three grades available for welding mild steel, armor plate and for overlays and welding hardenable steels.

Nickel base, magnesium, and titanium wires are supplied as specials. Consult your nearest Airco Office or Authorized Airco Dealer for complete information.

welding
AT THE FRONTIERS OF PROGRESS YOU'LL FIND . . .

AIR REDUCTION PRODUCT

VISIT OUR BOOTH 334 — WELDING SHOW

APRIL 9-11, 1957 · PHILADELPHIA, PA.

AIRCO®

Offices and dealers in most principal cities

AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated
150 East 42nd Street, New York 17, N. Y.

On the west coast — Air Reduction Pacific Company

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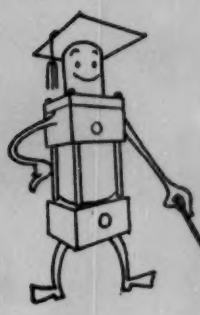
Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** — industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** — carbon dioxide — gaseous, liquid, solid ("DRY-ICE") • **OHIO** — medical gases and hospital equipment • **NATIONAL CARBIDE** — pipeline acetylene and calcium carbide • **COLTON** — polyvinyl acetate, alcohols, and other synthetic resins.

Miller

FLUID PRESSURE BOOSTERS

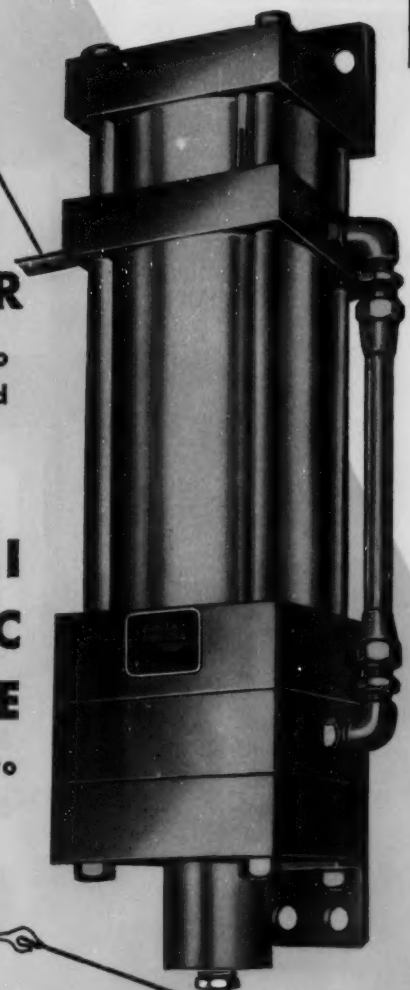


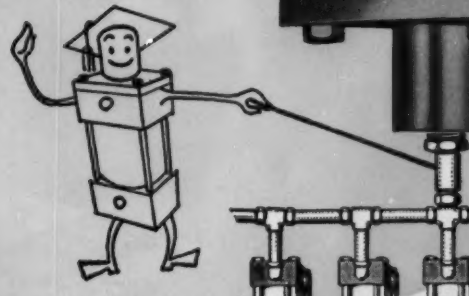
BOOST 80 PSI AIR

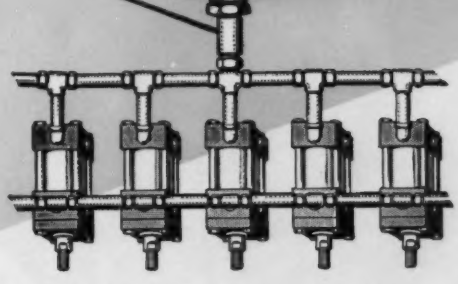
Input Range: 40 to 3000 psi Air or Fluid

TO 2000 PSI HYDRAULIC PRESSURE

Output Range: 200 to 10,000 psi Fluid

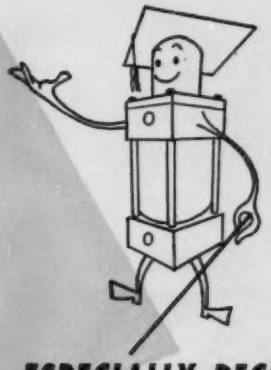






- Save space, weight and investment cost by replacing pump installations in many applications.
- Less costly to install, operate and maintain.
- **Hold Pressure indefinitely** without the motion and heat generation of ordinary pump circuits.
- Provide—at point of cylinder thrust—more efficient power with less weight in less space than direct driven air cylinders
- Save up to 95% of air consumed by direct driven air cylinders
- Operate at speeds of 30 to 450 strokes per minute.

NOTE: In addition to its most complete line of "Custom-Built" Boosters available on normal delivery Miller offers 5" bore, 25 to 1 ratio, boosters for immediate delivery in either 6" or 12" stroke. Write for data and prices.



ESPECIALLY RECOMMENDED FOR

- **WELDING**
- **PUNCHING**
- **SHEARING**
- **CLAMPING**
- **RIVETING**
- **CRIMPING**
- **PRESSING**

and similar applications

FULL DETAILS IN MILLER BULLETIN B-200 SENT FREE ON REQUEST
Other Miller products include: Air cylinders, 1½" to 20" Bores, 200 PSI operation; low pressure hydraulic cylinders, 1½" to 6" bores for 500 PSI operation, 8" to 14" bores for 250 PSI; high pressure hydraulic cylinders, 1½" to 12" bores, 2000-3000 PSI operation. All mounting styles available.

SALES AND SERVICE FROM COAST TO COAST

CLEVELAND • YOUNGSTOWN • DAYTON • PITTSBURGH • PHILADELPHIA • BOSTON • HARTFORD • NEW YORK CITY • BUFFALO • ST. PAUL • GRAND RAPIDS • DETROIT • FLINT • FORT WAYNE • SOUTH BEND • INDIANAPOLIS • MILWAUKEE • LOUISVILLE • KANSAS CITY • SEATTLE • LOS ANGELES • SAN FRANCISCO • BALTIMORE • DENVER • ST. LOUIS • MOLINE • CHICAGO • HOUSTON • TORONTO, CANADA and OTHER AREAS

Miller

MILLER FLUID POWER DIVISION FLICK-REEDY CORP.

2006 N. Hawthorne Ave., Melrose Park, Ill.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

Circle 447 on page 19

New Revere Aluminum Sheet Mill
Chicago, Ill.

You will find that Revere Aluminum Sheet passes smoothly and economically through your processes, that it brings to your products all the advantages you expect from fine aluminum.

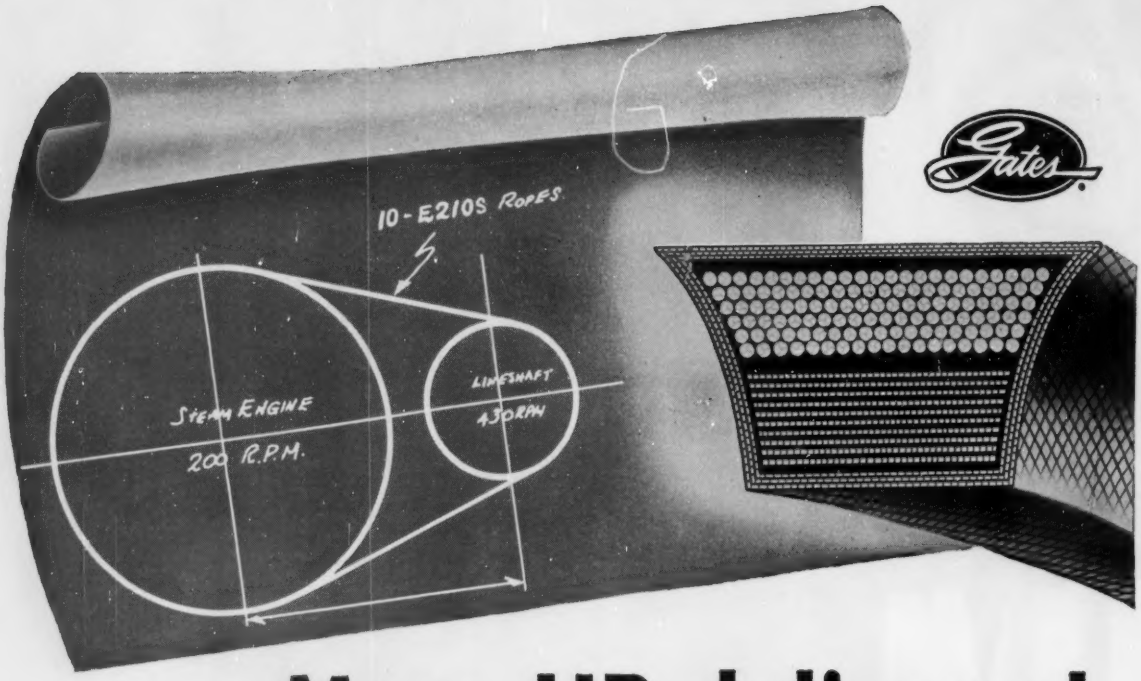
Three Revere plants, located in the East, the Mid-West and on the Pacific Coast, can bring mill service and technical consultation close to your own doorstep. These plants will have the backing of Revere's primary aluminum operation, scheduled to begin production in 1958.

It will pay you to tie the growth of your business to the most dependable sources of supply—such as Revere, which is in aluminum in a BIG WAY. Revere Copper and Brass Incorporated. Founded by Paul Revere in 1801. Executive Offices: 230 Park Avenue, New York 17, N. Y.

Revere Aluminum Mill Products include coiled and flat sheet, both plain and embossed, circles, blanks, Tube-In-Strip, extruded products, seamless drawn tube, welded tube, rolled shapes, electrical conductors, forgings, foil and frozen food containers.

← Projected for 1957: New Revere Aluminum Sheet Mill Santa Ana, Calif.

Circle 448 on page 19



More HP delivered per $ invested

On any new drive design—where you have limited space or you need to keep weight down—here is an important fact that can save you money:

A Gates Super Vulco Rope drive will deliver more horsepower per dollar invested than any standard V-belt drive.

Actually, the greater load carrying capacity of Super Vulco Ropes cuts down the number of belts required (5 Super Ropes do the work of 7 standard belts) . . . thus reducing the width of sheaves.

Sheaves with fewer grooves not only cost less, they weigh less, and take up less room—advantages that can easily improve the design and lower the overall cost.

A wealth of drive data is quickly available to you. Simply call your nearby Gates V-Belt Distributor (see 'phone book yellow pages) for a Gates V-Belt Specialist. Stocks available in industrial centers around the world. The Gates Rubber Co., Denver, Colorado—*World's Largest Maker of V-Belts.*

4 BIG PLUSES

✚ Handles shock loads

Super-strength cords provide 40% greater horsepower capacity . . . easily absorb heavy shock loads.

✚ Provides Static Safety

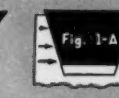
High electrical conductivity is built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

✚ Resists oil, heat and weather

Special rubber compounds with which cords and fabric are impregnated make Super Vulco Ropes highly resistant to heat, oil and prolonged exposure.

✚ Wears far longer

Concave Sidewalls (Fig. 1) increase belt life. As belt bends, concave sidewalls (U.S. Pat. No. 1813698) become straight, make uniform contact with sheave groove (Fig. 1-A). Uniform contact means less wear on sides of belt . . . longer V-belt life.



Flex-Weave cover (U.S. Pat. No. 2519590) provides greater flexibility with far less stress on fabric. Cover wears longer—increases belt life.

TPA 76A

GATES SUPER VULCO ROPE DRIVES

The performance and the name are the same around the world

MACHINERY MANUFACTURERS:

The performance of Shell Alvania Grease enjoyed by your domestic customers is available abroad. And this same uniformity applies to

SHELL TURBO OIL—gives anti-wear lubrication for utility, industrial and marine turbines

SHELL TELLUS OIL—lubricant and control fluid for complex hydraulic systems, and a complete line of other

SHELL INDUSTRIAL LUBRICANTS

Shell Alvania Grease, used world-wide as a multi-purpose lubricant, has an outstanding performance record in solving many of the toughest anti-friction bearing grease problems. Ideal for wet, humid applications (inhibited to prevent water corrosion), it lubricates under water-wet conditions which normally spell trouble.

Alvania* Grease has the added advantage of remaining plastic in sub-zero weather and stable under sustaining high temperatures. This one grease successfully replaces dozens of special lubricants in plant after plant . . . reason enough for its universal popularity. For complete information, write Shell Oil Company, 50 West 50th St., New York 20, N. Y., or 100 Bush St., San Francisco 6, Calif.

*Trademark

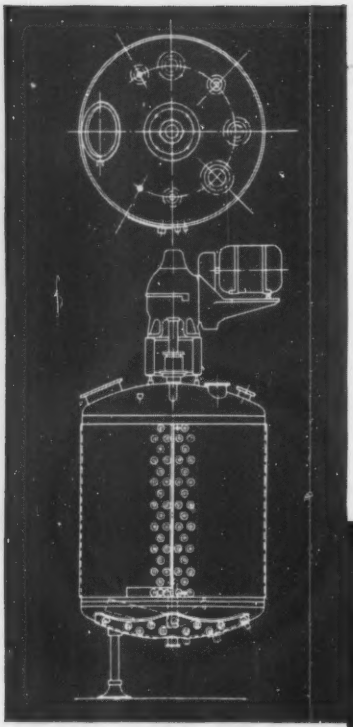
SHELL ALVANIA GREASE

A TRULY MULTI-PURPOSE LUBRICANT

SHELL

Circle 450 on page 19

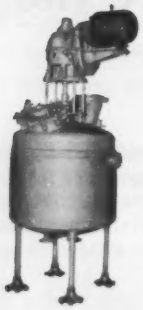
can you afford not to use TITANIUM?



By themselves, catalog prices of raw materials can be misleading. For it's the final cost—in terms of service life—that really determines what you pay for equipment.

The following table, based on cost analysis by the Pfaudler Company, indicates their estimate of comparative costs of producing the reactor unit shown at the left, using titanium, and two other well-known, corrosion-resistant metals.

	REM-CRU A-55 TITANIUM	METAL A	METAL B
Cost per lb.	$14.60	$0.8025	$2.62
But titanium's light-weight means less is needed . . .			
Material Required	250 lbs.	785 lbs.	675 lbs.
So the comparative cost factor is reduced . . .			
Material Costs	$3650.00	$630.00	$1768.00
Fabrication takes the lions' share, so . . .			
Cost of Finished Reactor	$12,150.00	$2391.00	$4670.00
And in corrosive chlorides, hot acids, and many other environments, laboratory and service data show . . .			
Service Life	5 years	6 months	1 year
NOW . . . COST Per Service Year	**$2430.00**	**$4782.00**	**$4670.00**



Reactor unit of REM-CRU titanium built by the Pfaudler Co., Rochester, N. Y. and Elyria, Ohio a skilled fabricator of titanium and other corrosion-resisting materials.

Don't be fooled by raw material costs alone—*it's the cost per service year that really counts.* Then, too, down-time losses while equipment is being replaced can quickly mount up. Another plus for longer-lasting titanium. Why not let a REM-CRU engineer help you make the best, most profitable use of titanium?

To keep abreast of the latest developments on this vital metal, write to Dept. MD-4 for the Rem-Cru Review—a free periodical presenting the latest technical data on titanium alloys.

REM-CRU TITANIUM

REM-CRU TITANIUM, INC., MIDLAND, PENNSYLVANIA

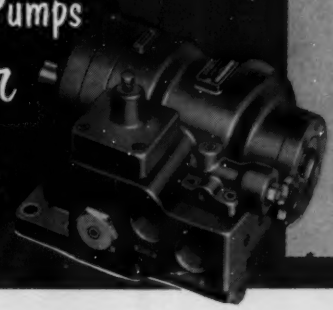
Sales Offices: 3338 South Malt Avenue, Los Angeles 22, California • 4501 W. Cortland Street, Chicago 39, Illinois • 405 Lexington Avenue, New York 17, N. Y.

Circle 451 on page 19

Do You Want To Save Horsepower and Heat?

VICKERS®

Two-Pressure Oil Hydraulic Pumps Require Less Power for Two-Pressure Circuits



Automatically Provide

High Volume @ Low Pressure for fast closing, rapid advance, and rapid return.

Low Volume @ High Pressure for feeding, compressing, clamping, and holding.

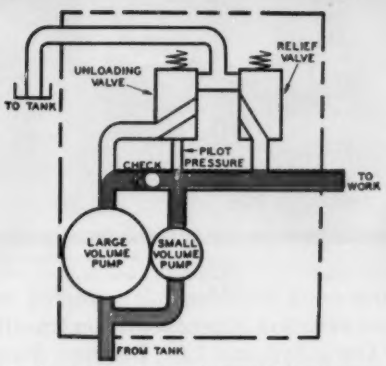


Fig. 1 Combined Delivery of Large and Small Volume Cartridges at Low Pressure

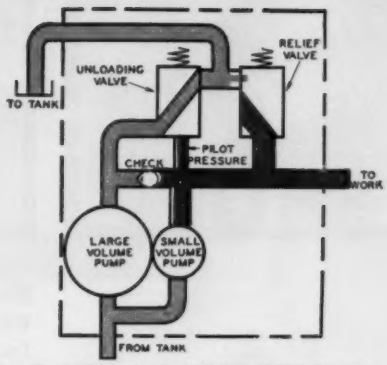


Fig. 2 Delivering Small Volume at High Pressure

Two Vickers Vane Type pumping cartridges are mounted on the same shaft—in the same housing, driven by the same prime mover. One provides a large volume of oil while the other delivers a small volume. These Vickers Two-Pressure Pumps have proved advantageous in a wide variety of applications.

For example, in closing a press or in rapid advance, both pump cartridges work together, supplying maximum volume for quick operation (see Fig. 1). When the press is closed and compression begins, or when the tool goes into feed immediately prior to beginning the cut, the large volume cartridge is automatically unloaded to the reservoir at zero pressure (see Fig. 2). The small volume cartridge alone then provides the lower volume required at high pressure.

These Vickers Two-Pressure Pumps are most economical in power consumption for such two-pressure operation. The reason for this is that a small-volume pump working at full capacity is MORE EFFICIENT than a large-volume pump working at partial capacity. Regardless of momentary delivery, the internal leakage of any pump is proportional to its size and operating pressure. The chart (Fig. 3) shows an interesting comparison between a Vickers Two-Pressure (Two-Volume) Pump and a variable volume vane type pump on a press circuit.

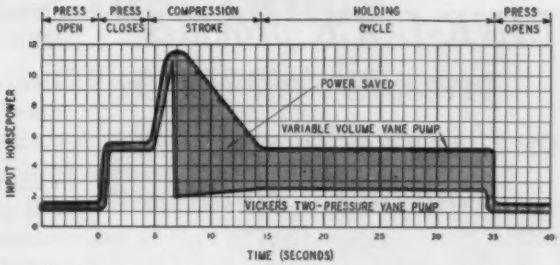


Fig. 3. On this typical press application the saving in power is approximately 50% with a resultant saving in heat in the system.

Like all Vickers Vane Pumps, these two-pressure pumps have the hydraulic balance feature that relieves bearings of all pressure loads (one of the major causes of wear). Cartridge construction enables customer to service in his own plant instead of returning to factory should repairs be necessary. Relief and unloading valves are integral . . . minimizing piping and connections. Complete range of sizes up to 48 gpm. For additional information, ask for Bulletin 54-70a.

6895

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan

Application Engineering Offices: ATLANTA • CHICAGO • CINCINNATI • CLEVELAND • DETROIT • GRAND RAPIDS • HOUSTON LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Summit, N. J.) • PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) • PORTLAND, ORE. • ROCHESTER ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • ST. LOUIS • TULSA • WASHINGTON • WORCESTER
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto

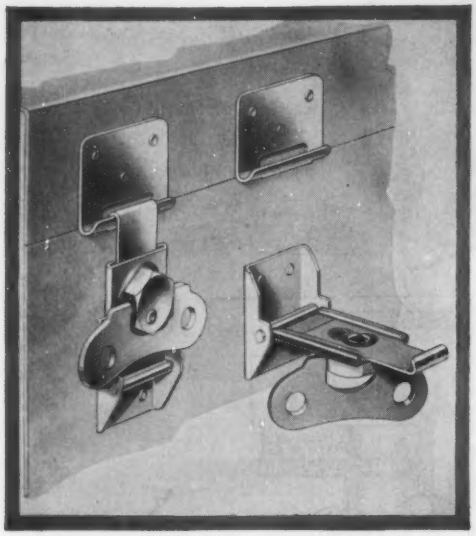
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

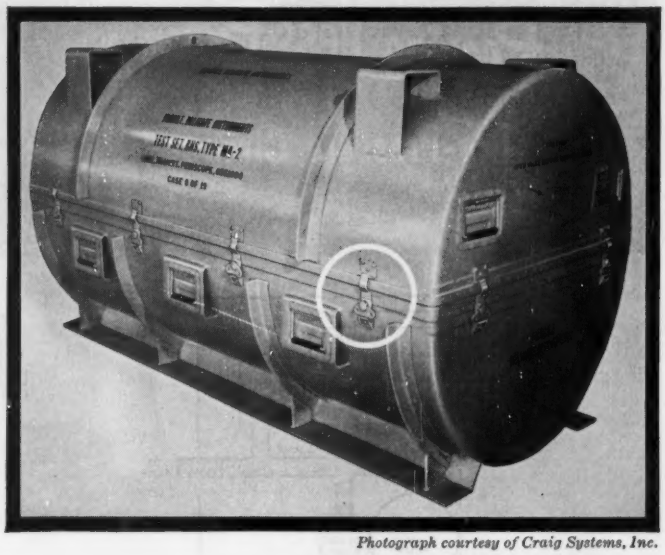
Circle 452 on page 19

Note—Commercial and Military Packaging Engineers:

Rugged LINK-LOCK

...your best answer to exacting closure problems





Photograph courtesy of Craig Systems, Inc.

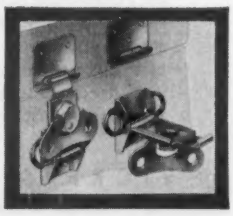
LINK-LOCK provides pressure-tight closure on this rigidly specified equipment container

Simmons LINK-LOCK provides quick opening and closing as well as impact-resistant dependability on transit cases manufactured by Craig Systems, Inc., Danvers, Mass.

The cylindrical Craig container above is gasketed and pressure-tight, and contains delicate electronic equipment. Twelve LINK-LOCK fasteners are used on this model.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

- Impact and shock resistant (positive-locking).
- High closing pressure with light operating torque..... insures pressure-tight seals where required.
- Available in 3 sizes, for heavy, medium, and light duty.
- Compact design...lies flat against case even when unlocked.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design...can be varied to suit different conditions.



Also available: Spring-Loaded LINK-LOCK. Ideal for the less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

Where does the versatile Simmons LINK-LOCK belong in your design? For complete information and specifications, send for the Simmons Catalog today. Samples and engineering service available upon request.

VISIT OUR EXHIBIT
Booth 528
1957 DESIGN ENGINEERING SHOW
New York Coliseum, May 20-23

SIMMONS
FASTENER CORPORATION
1756 North Broadway, Albany 1, New York
QUICK-LOCK • SPRING-LOCK • ROTO-LOCK • LINK-LOCK • DUAL-LOCK

Circle 453 on page 19

AUTOMATIC *Air-Borne* LUBRICATION

FOR ALL ELEMENTS OF A MACHINE

One Lubricator Per Machine — Model 33AL-4 (½") Lubrication Unit automatically creates finely divided air-borne oil fog. Completely lubricates a machine having a maximum requirement of 100 bearing inches.

Better Lubrication — Continuously applies protective film of fresh oil to lubrication points. Never periods of too much or too little lubrication.

Compact, Complete, Attractive — Measuring only 6-1/32" x 6-1/32" x 5-3/16", cabinet contains air filter, pressure regulator, MICRO-FOG Lubricator.

Visual Oil Feed — Oil feed is readily visible, providing positive proof of lubrication. No guesswork.

For complete information on MICRO-FOG Lubrication for all bearing inch requirements, call your nearby Norgren Representative listed in the telephone directory — or WRITE FOR FACTORY LITERATURE.

C. A. NORGREN CO.

3442 SOUTH ELATI STREET • ENGLEWOOD, COLORADO

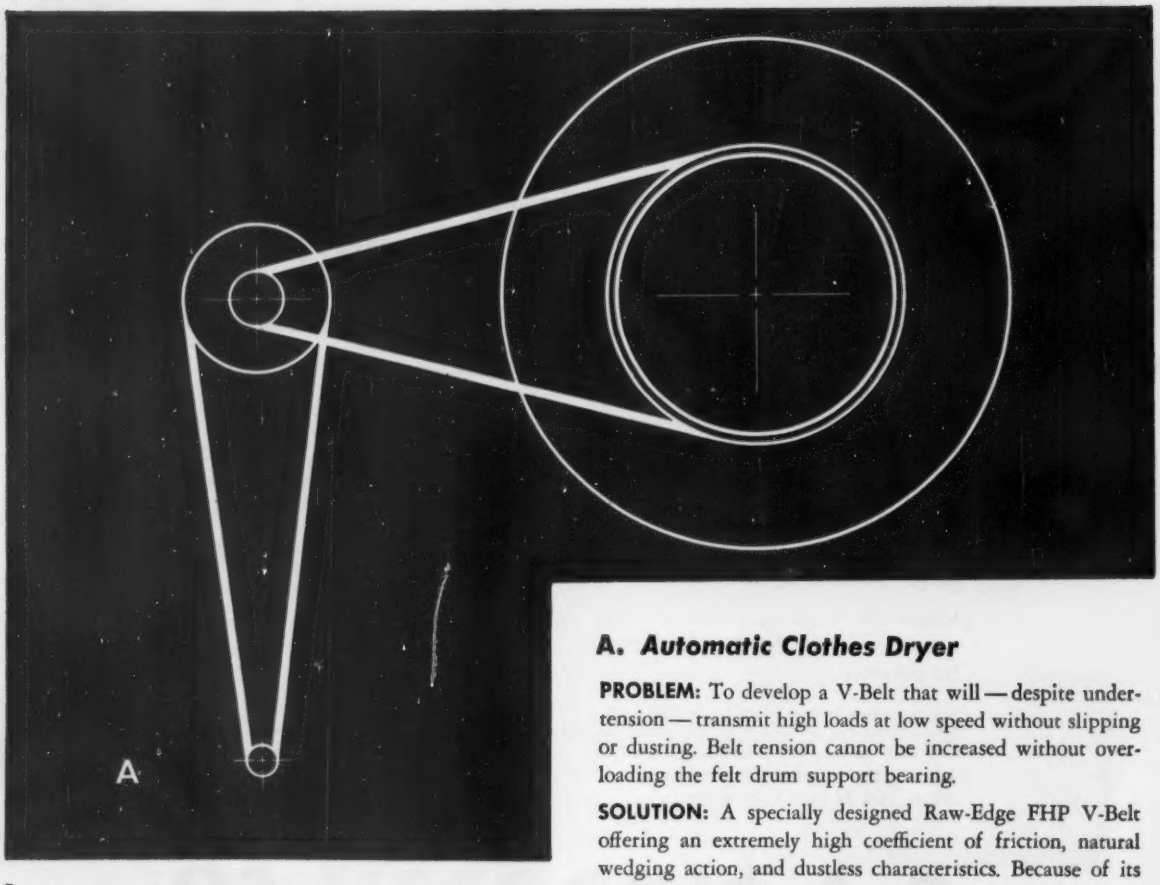
How 3 dissimilar drive problems were solved with special Dayton Raw-Edge FHP V-Belts

THE PROBLEMS:

A. *To transmit high loads using sub-diameter pulleys*

B. *To transmit high loads at variable speeds without vibration*

C. *To transmit high loads with minimum V-Belt tension*

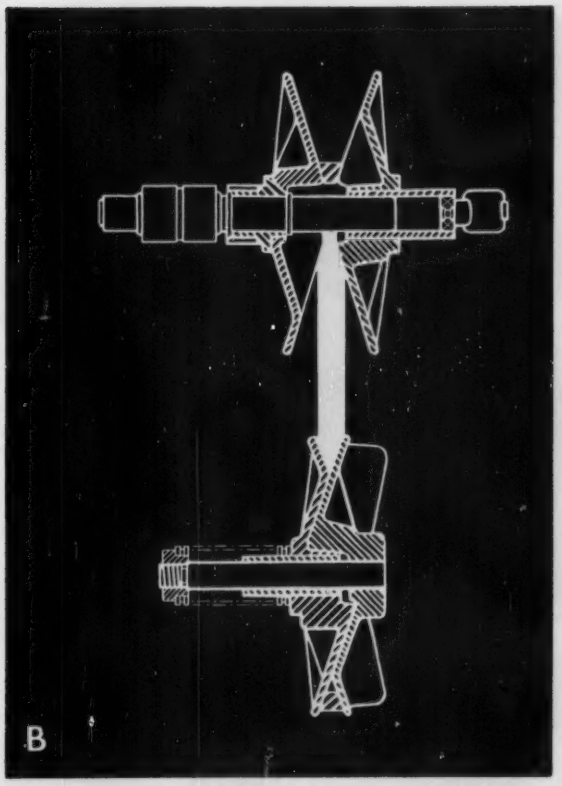


A. *A noteworthy feature of this automatic clothes dryer is the use of a rolled flange on the dryer drum as the final pulley in a 35:1 two-stage reduction drive. The dryer drum is supported by felt bearings.*

A. *Automatic Clothes Dryer*

PROBLEM: To develop a V-Belt that will — despite under-tension — transmit high loads at low speed without slipping or dusting. Belt tension cannot be increased without overloading the felt drum support bearing.

SOLUTION: A specially designed Raw-Edge FHP V-Belt offering an extremely high coefficient of friction, natural wedging action, and dustless characteristics. Because of its high traction ability, the raw-edge belt will pull the load required without the high tension which would collapse the belt bearing. The inherently dustless characteristic of Raw-Edge V-Belts allows clean operation.



B. *Interdigitary pulleys are employed by a popular home workshop tool to provide an extraordinarily wide range of variable speeds within a limited drive space. By this unique method, the pitch diameter of each pulley can be varied from 1-1/2" to 5-3/16".*

B. *Multi-Purpose Home Workshop Tool*

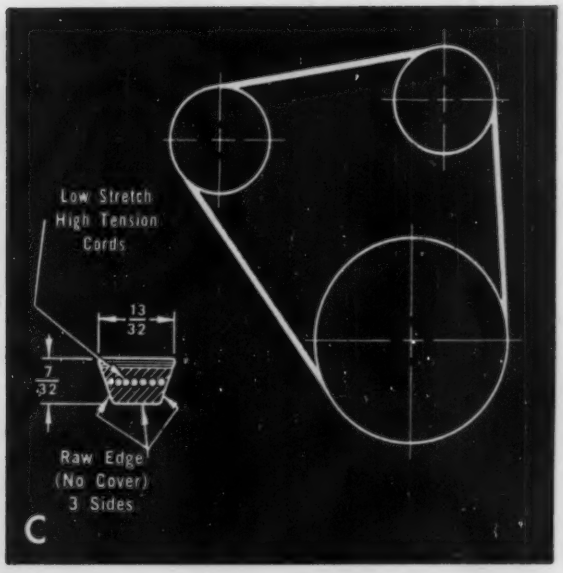
PROBLEM: To transmit heavy loads with interdigitating variable speed pulleys without vibration. The required V-Belt must not take a set due to long periods of idleness and — for safety — must slip under overload.

SOLUTION: A special Raw-Edge Die-Cut V-Belt compounded from special rubbers and fabrics which can be used only in Raw-Edge construction. A full plyed-up section, manufactured under especially close width and length controls, was the solution to this problem. The belt in use

— has the required coefficient of friction to transmit heavy loads and slip under overload

— won't take a set even when stored under tension for long periods

— has the ability to flex over small diameter pulleys



C. *Because of the extreme compactness of a space saving design, this automatic clothes washer employs small diameter pulleys.*

— resists twisting when operating over the interrupted surface of the interdigitary pulleys and thus avoids setting up vibration.

C. *Automatic Clothes Washer*

PROBLEM: Small diameter pulleys with a limited arc of contact caused belt slippage and premature failure in a drive operating at high speed and under heavy loads. Tension adjustment was limited and somewhat inaccessible.

SOLUTION: Employment of a special Raw-Edge Molded FHP V-Belt, with its high coefficient of friction and inherent wedging action, to attain high tractive effort despite the limited arc of contact. As a further refinement, the belt being furnished by Dayton is built with special "low stretch" cords in the strength section to minimize the need for tension adjustment. This solution made redesigning around larger pulleys and heavier belts unnecessary.

Dayton's V-Belt Engineering Service

For help on your drive designs, Dayton Engineers are at your service with the correct V-Belt to fit all your requirements.

To contact one of these V-Belt Design Specialists or for more information on special Raw-Edge FHP V-Belts, write The Dayton Rubber Company, Industrial O.E.M. Division, Dayton 1, Ohio.

THE DAYTON RUBBER COMPANY, INDUSTRIAL O. E. M. DIVISION, DAYTON 1, OHIO

Dayton Rubber

WORLD'S LARGEST MANUFACTURER OF V-BELTS

Industrial Sales Engineers in Atlanta, Chicago, Cleveland, Davenport, Dayton, New York, San Francisco and St. Louis.

A Man Nobody Wants

This one is always on the move but never on the go. His movement is aided by lead, well placed immediately above the seat of the swing. On the wall of his office is a large sampler lovingly embroidered: "Home, Sweet Home." That is his personal creed and he keeps trying to get the whole company to adopt it.

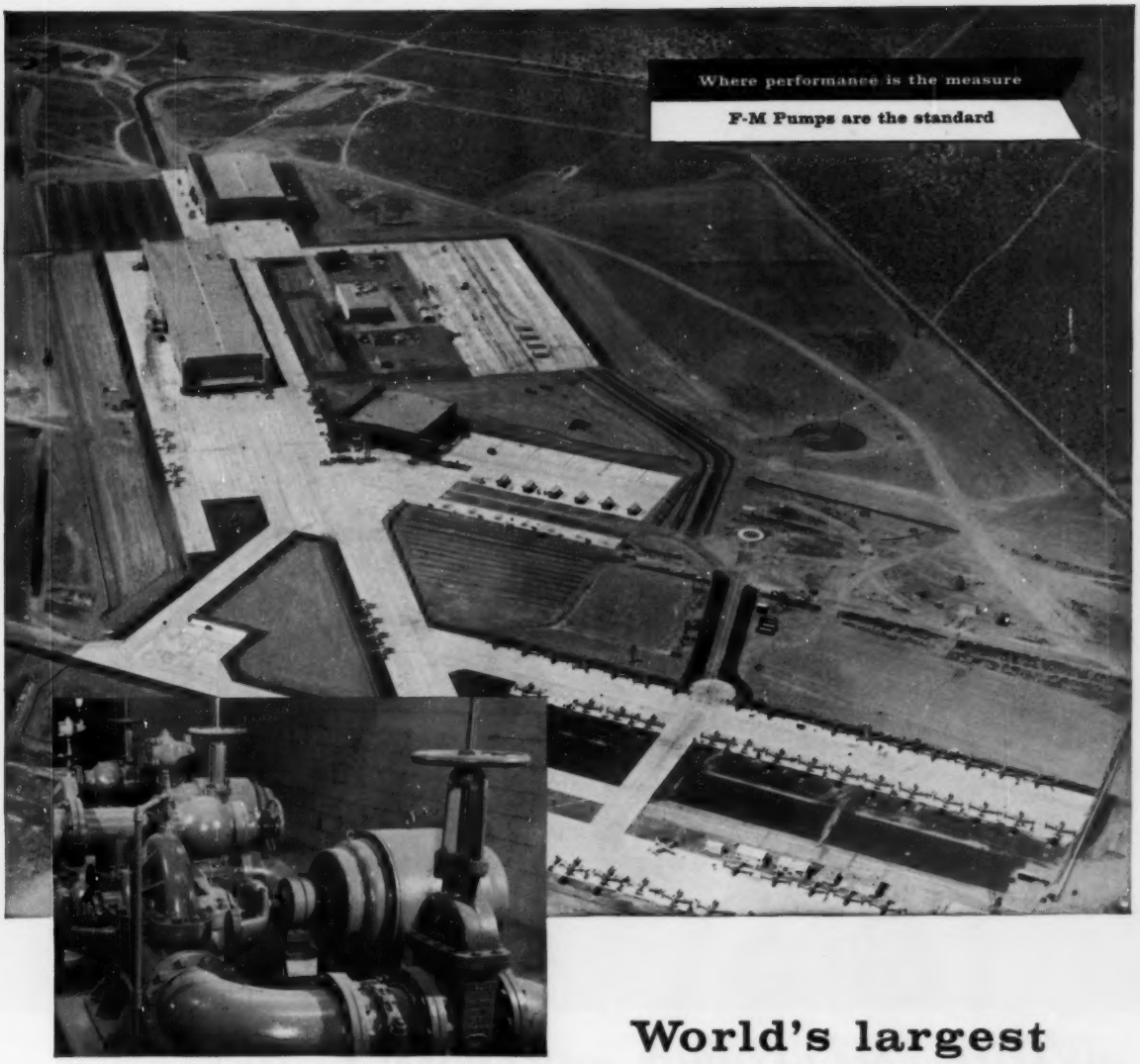
As his orbit is unchanging, he will never find Rogers. But Rogers will not brood over his continued absence.

For Rogers serves engineers – those men who swoop purposefully across the heavens, searching the stars for new points of reference. An ever-growing body of such men is finding Rogers a dependable ray of light in terms of engineered materials – special formulations as different and daring as the ideas that engendered them.

Samples – and both down-to-earth and up-in-the-clouds literature – will be sent to any engineer. Please let us have your name and address.

ROGERS
CORPORATION
ROGERS, CONNECTICUT

DUROIDS—for Gaskets, Filters, Electronic Devices, Thermal Insulation, etc. ELECTRICAL INSULATION—for Motors, Transformers, Generators, etc.
SHOE MATERIALS—for Counters, Midsoles, Liners, etc. PLASTICS—Special Purpose Molding Compounds and Laminates RUBBER—for Floats, Grommets, Gaskets, Bearing Seals, etc.
FABRICATING—Including Converting, Combining, Coating, Embossing, and Molding DEVELOPMENT—Research and Engineering of Unique Materials, Parts and Products



Fairbanks-Morse fire pumps provide 12,000 gpm. of water at 100 psi. for each of two systems.

World's largest jet aircraft center protected by F-M fire pumps

Four major aircraft companies—Lockheed, North American, Convair and Northrop—use the 5000-acre U. S. Air Force Plant No. 52 at Palmdale, Calif., for assembly and testing.

Maximum protection against fire at this gigantic operation was achieved at minimum cost by installing two identical, interlocking water supply systems, each equipped with Fairbanks-Morse pumps for both water supply and sprinkler pressure.

The size and scope of this installation indicate Fairbanks-Morse's ability to supply fire pumps for all magnitudes of industrial and municipal requirements. Whatever your needs in fire protection—big installations or small—your Fairbanks-Morse Field Engineer will be glad to work with your own engineers, in specifying the most efficient equipment. Call him today, or write Fairbanks, Morse & Co., Dept. MD-4-18, 600 So. Michigan Ave., Chicago 5, Ill.

FAIRBANKS-MORSE

a name worth remembering when you want the BEST

PUMPS • SCALES • DIESEL LOCOMOTIVES AND ENGINES • ELECTRICAL MACHINERY • RAIL CARS • HOME WATER SERVICE EQUIPMENT • MOWERS • MAGNETOS

Circle 457 on page 19

Circle 458 on page 19→

A Man Nobody Wants

This one is always on the move but never on the go. His movement is aided by lead, well placed immediately above the seat of the swing. On the wall of his office is a large sampler lovingly embroidered: "Home, Sweet Home." That is his personal creed and he keeps trying to get the whole company to adopt it.

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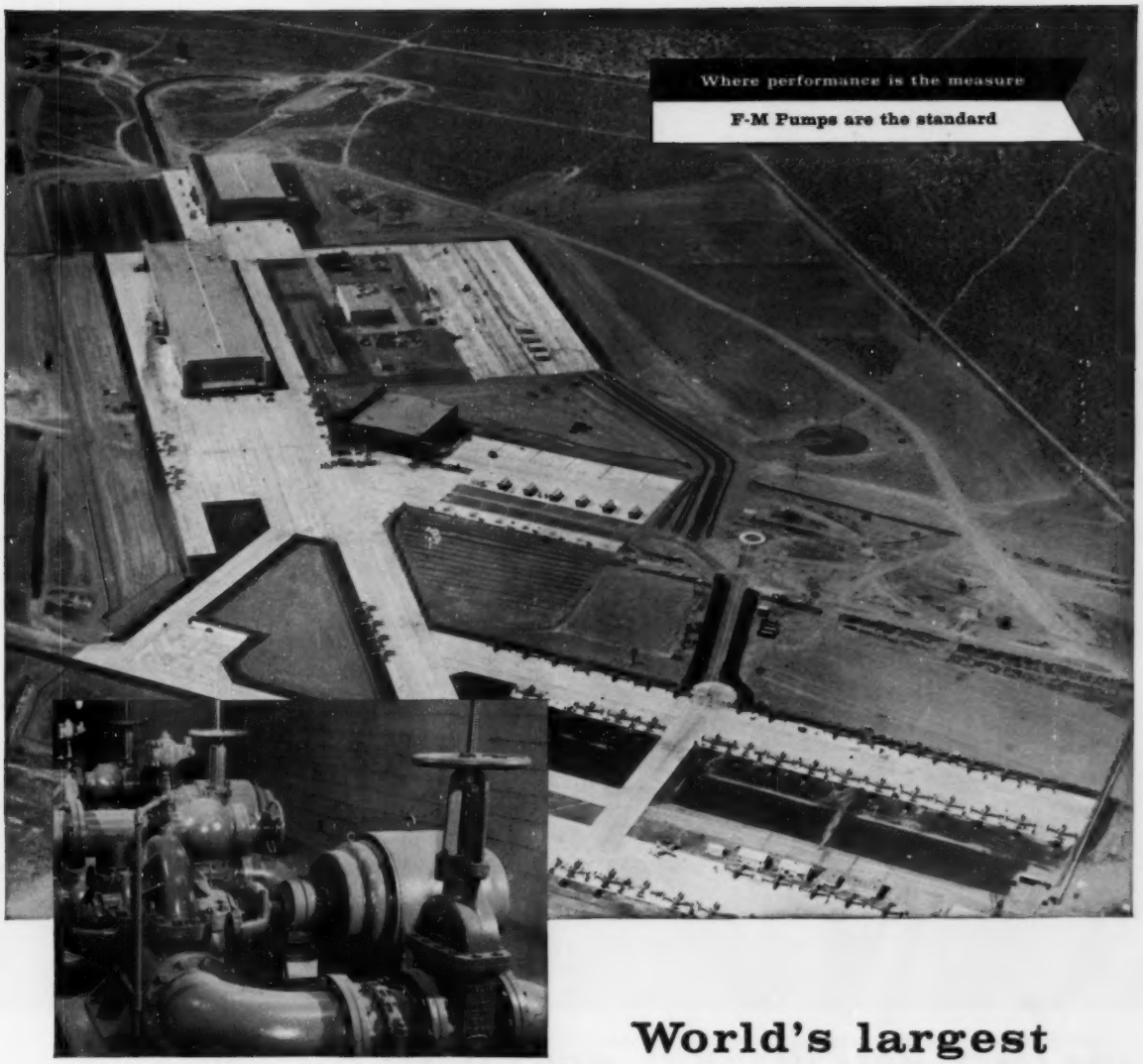
SHOE MATERIALS—for Counters, Insoles, Liners, etc. PLASTICS—Special Purpose Molding Compounds and Laminates RUBBER—for Floats, Grommets, Gaskets, Bearing Seals, etc.
FABRICATING—Including Converting, Combining, Coating, Embossing, and Molding DEVELOPMENT—Research and Engineering of Unique Materials, Parts and Products



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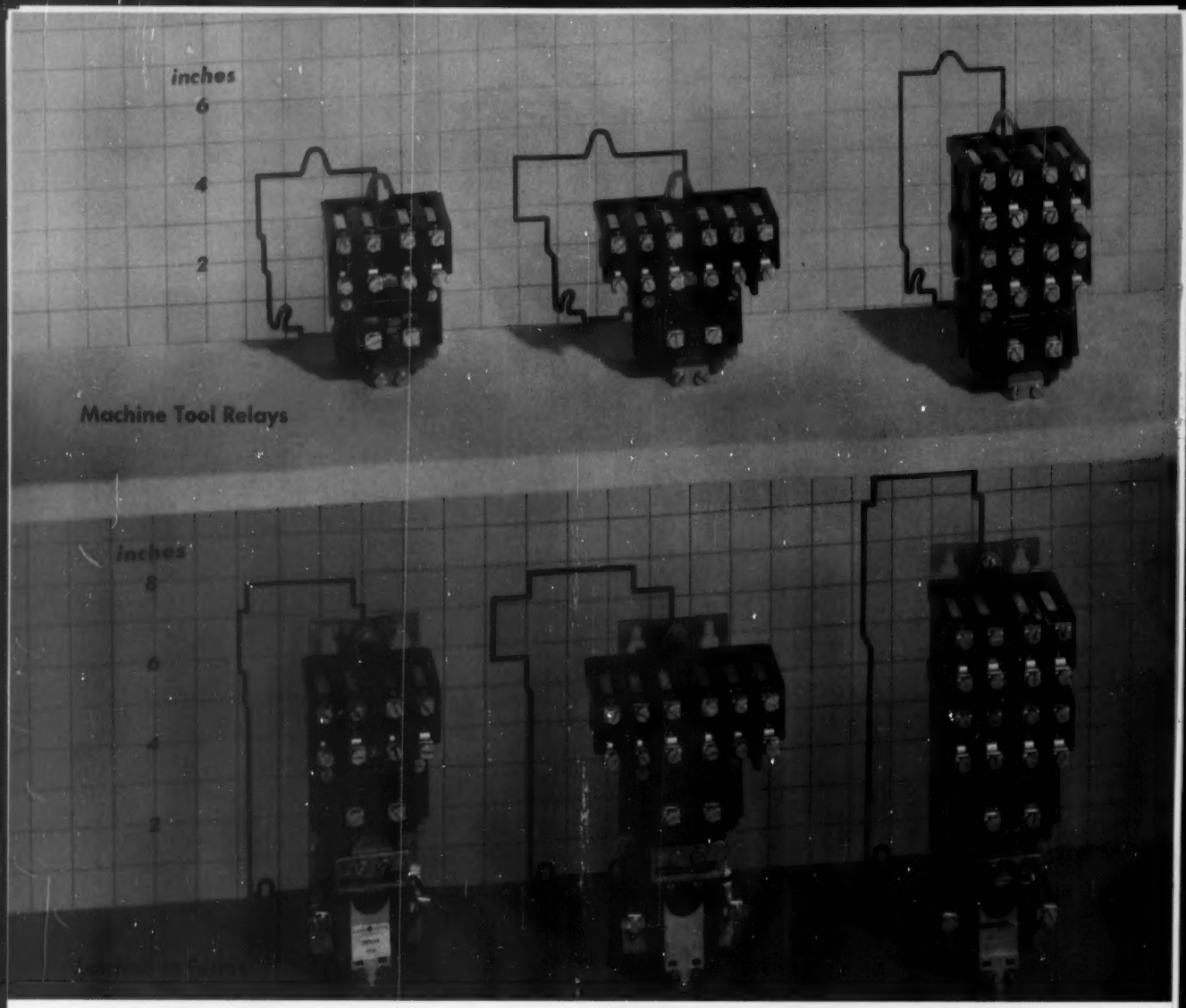
Circle 457 on page 19

Circle 458 on page 19→



LESS SPACE, MORE FLEXIBILITY, WITH GENERAL ELECTRIC'S–

New Machine Tool and Pneumatic Time-

Machine Tool Relays Require Minimum Mounting Space

General Electric's new relays provide the installation features and long life required by the machine tool industry.

MINIMUM MOUNTING SPACE is required for all the relays—2- through 12-poles. New 6-pole-in-line and 12-pole forms have the same mounting dimensions as the 4- and 8-pole forms respectively.

INSTALLATION and wiring is performed from the front, allowing relays to be mounted close together. The captive clamp-type terminals can be wired from four directions. In addition, contacts can be changed from normally-open to normally-closed without extra parts.

RATING is 10 amps, 600 volts maximum, a-c. Latched-in forms are also available.

Pneumatic Time-Delay Relays Provide High Repetitive Accuracy

The new General Electric pneumatic time-delay relay was designed for applications which require a reliable and accurate time-delay device.

FLEXIBILITY of pneumatic time-delay relay design allows the relays to be supplied with either one or two instantaneous auxiliary contact units, and one or two time-delay contact units. The timing head is available separately for use with Size 0 through 4 contactors and Size 1 through 4 magnetic starters.

HIGH CONTACT RATING of 25 amps "make and carry" at 600 volts maximum means that supplementary relays can often be eliminated. In addition, pneumatic timers can be front mounted and wired for further space savings.

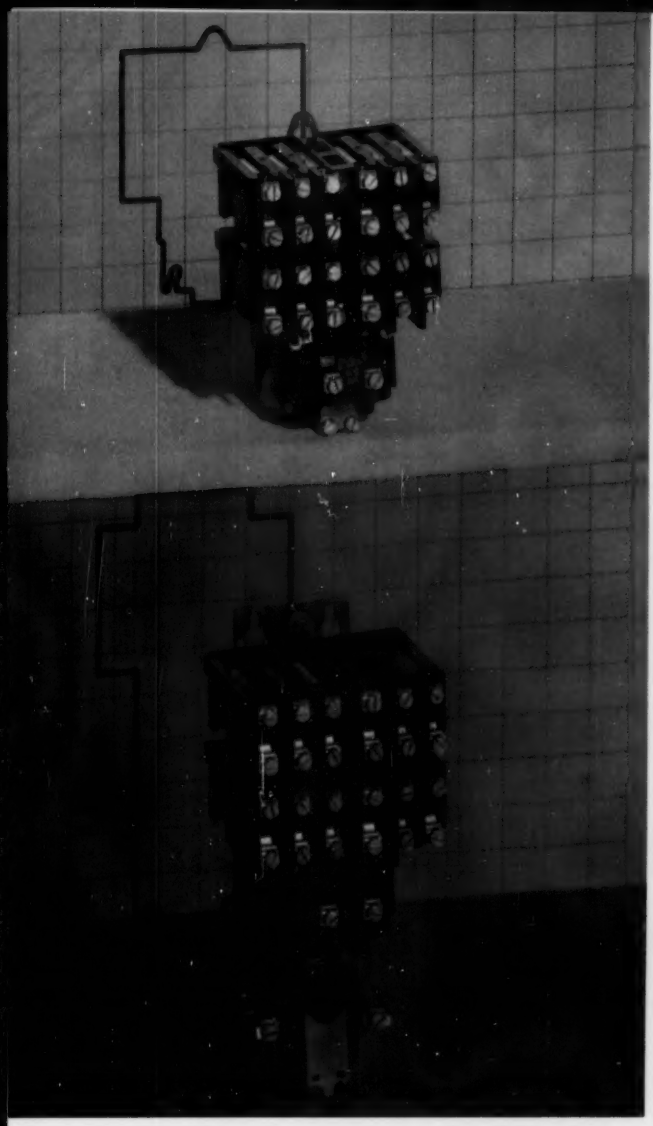
ADJUSTABLE TIME-DELAY permits the timer to be set for any time-delay interval from 0.2 to 180 seconds. Repetitive accuracy is ± 10%, and is not affected by atmospheric conditions. Adjustment is made by a simple screwdriver setting on the front of the unit.

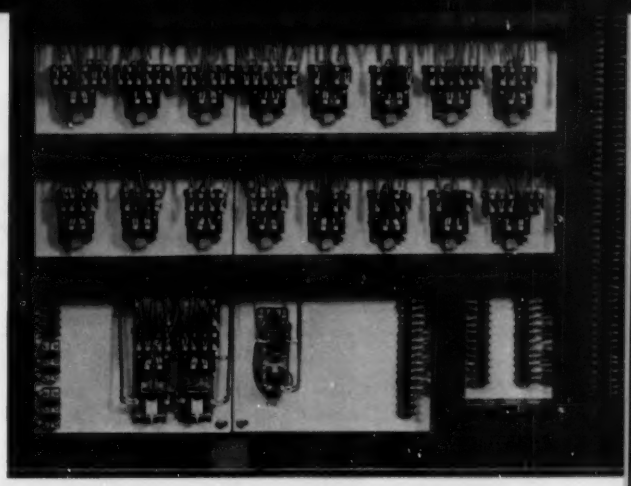
DEPENDABILITY results from many built-in protective features. A special filter mounted in a vertical position in the rear keeps dust and dirt out of the air port. Also, rigid cast construction prevents misalignment.

Relays Used on Pan-A-trol* Panels

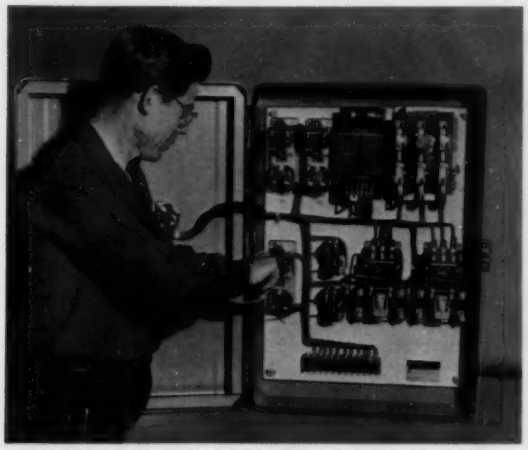
Using machine tool relays, pneumatic time-delay relays, and other standard control devices, G-E engineers build Pan-A-trol packaged control panels to meet your requirements and specifica-

*Trade-mark of General Electric Company





G-E RELAYS permit neat panel mounting arrangement. If desired, relays and wiring troughs may be mounted closer.



PAN-A-TROL PANELS utilize standard components like the new G-E relays, and are factory assembled and wired.

PNEUMATIC TIME-DELAY RELAYS can be modified easily with kits. Also, the timing heads are available separately.

Delay Relays

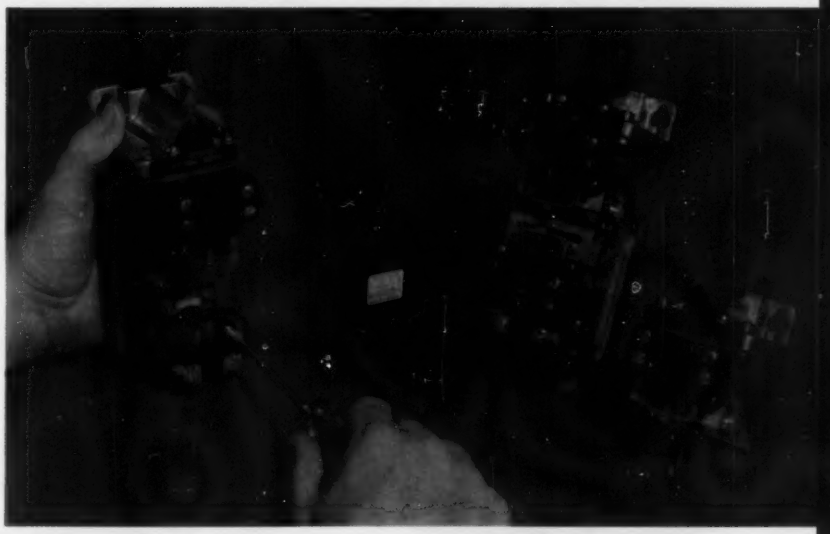
tions. These panels are completely assembled and wired at the factory; only external connections to the machine need be made. Pan-A-trol panels represent another offering by General Electric to simplify the work of design engineers.

Your nearest G-E Apparatus Sales Office can give you complete details on General Electric control devices and on the Pan-A-trol program. If you'd like reference material, write Advertising Section 731-11, General Electric Company, Bloomington, Illinois, and ask for:

GEC-1415 and 1416—Machine Tool Relays

GEC-1425—Pneumatic time-delay Relays

GEA-6334—Pan-A-trol panels



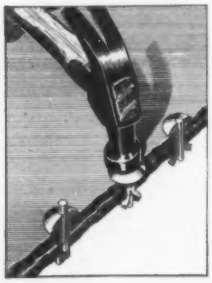
GENERAL ELECTRIC

MANY FACTORS CONTRIBUTE TO LOW INSTALLED COST OF SOUTHCO DRIVE RIVETS . . .

ECONOMICS OF FASTENING COVERS FULL CYCLE FROM INVENTORY REQUIREMENTS TO FINISHED PRODUCT

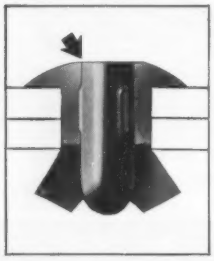
Designers who specify fasteners realize the many considerations that enter into cost determination. While ease of installation is often the most important feature, other factors affect costs. It may be difficult to put a dollar value on availability, for example, but serious financial losses do occur when production is held up or shipping dates are missed because of a slow fastener delivery. Being able to ship from stock, as Southco does, helps avoid production delays.

ELIMINATION OF SPECIAL TOOLS



Down time due to special tool failure and maintenance of special fastening tools are two fastening costs which are eliminated by Southco Drive Rivets. The only tool required is a hammer . . . any kind of a hammer . . . claw or ball, and size is not important. The number of men on a Southco riveting job is never limited by the number of special tools on hand and in working order.

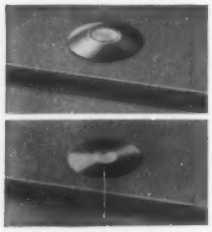
QUICKLY SET



To install, Southco Rivets are placed in drilled hole. The pin is then driven with a hammer. Installation is complete. No bucking is required.

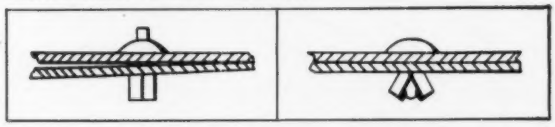
Expanded prongs force parts together. Pin is locked securely into rivet by displaced metal filling unique grooves. Compression forces are utilized for greater strength.

NO FINISHING OFF, NO WASTE



Impact of hammer seals pin neatly in rivet. No part of the rivet is cut off and discarded. No time-consuming filing, grinding or polishing is necessary. No scrap to clean up.

AUTOMATIC "PULL-UP" ACTION ASSURES TIGHT JOINT



Even when adjacent surfaces are separated, parts are forced together by Southco Rivet action, then held tightly in compression.

WIDE RANGE OF APPLICATION

Southco Drive Rivets are used to secure metal to metal or metal to wood. They are equally adaptable to blind or open applications. In each, they are quickly set and grip tightly. New PLY-HEAD* rivet permits higher loading of "soft" materials such as plywood, plastics and composition.

AVAILABLE IN ALUMINUM OR STEEL

Southco Rivets are supplied in aluminum or cadmium plated steel. The aluminum rivets have either cadmium plated or stainless steel grooved pins. The steel rivets have cadmium plated steel grooved pins.

Standard head designs are Universal or Countersunk. Full Brazier heads are available in popular sizes. New PLY-HEAD rivet rounds out line.

ALUMINUM

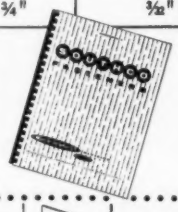
DIAMETERS	LENGTHS	NOMINAL GRIPS
1/8"	1/8" to 1/2"	1/32" to 13/32"
5/32"	7/32" to 3/4"	1/16" to 5/8"
3/16"	1/8" to 3/4"	1/32" to 5/8"
1/4"	7/32" to 3/4"	1/16" to 5/8"

STEEL

DIAMETERS	LENGTHS	NOMINAL GRIPS
1/8"	1/8" to 1/2"	1/32" to 13/32"
3/16"	1/4" to 3/4"	3/32" to 3/4"
1/4"	1/4" to 3/4"	3/32" to 5/8"

FREE FASTENER HANDBOOK . . . Send for your free copy of Fastener Handbook No. 7, just released. Gives complete engineering data on these and many other specialty fasteners. 52 pages, in two colors.

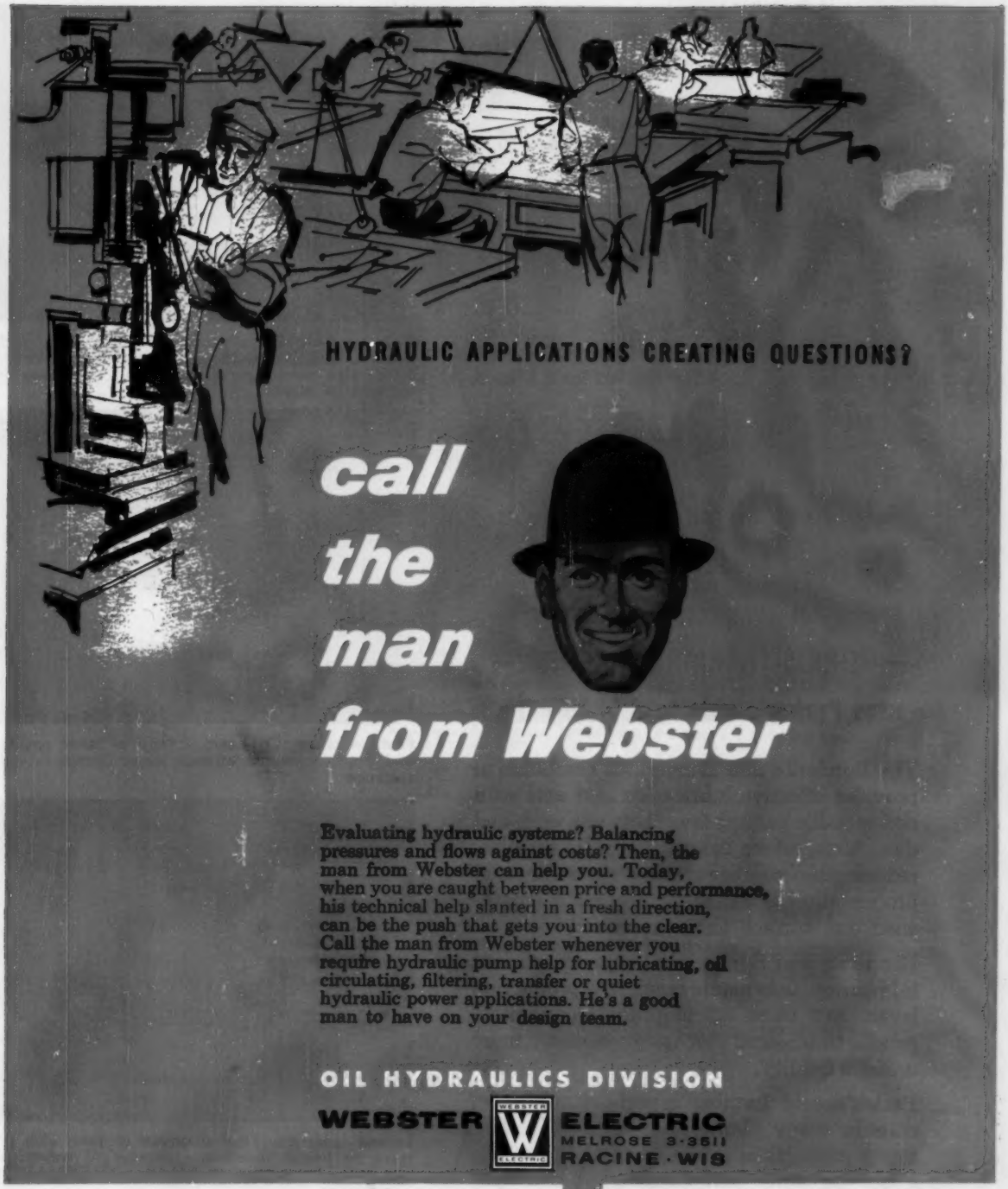
Write on your letterhead to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.



SOUTHCO FASTENERS

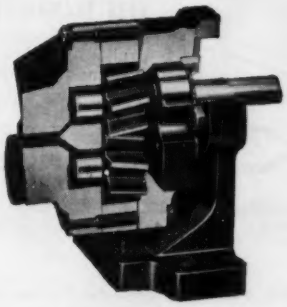
LION

©1957



OVER 100 MODELS

Capacities: *1/5 to 30 GPM*
Pressures: *Up to 1500 PSI*
Speeds: *Up to 3600 RPM*
Drives: *Direct or Geared*
Torques: *Up to 60 in. lbs./100 PSI*
Available with or without built-in relief valves



☐ *Have THE MAN FROM WEBSTER contact us—*

- Please send the following -

☐ *Complete hydraulic catalog of pumps and valves*

☐ *New information or data as published*

Name _____
Title _____
Company _____
Street _____
City _____ State _____

Circle 460 on page 19

Flat Blanks to Finished Cylinders...

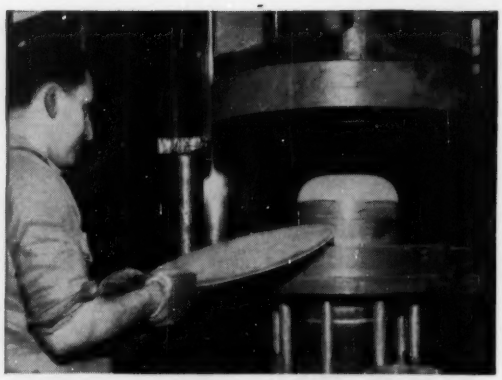
Higher Production Better Quality

one of the nation's foremost producers of cylinders for compressed gases —NORRIS-THERMADOR CORP.— uses Parker's aids to cold forming

The Bonderite and Bonderlube combination provides effective lubrication and acts as a non-metallic parting layer between work and dies. More severe deformations are possible, reducing the number of press operations and process anneals necessary. Die life is lengthened and surface finish improved.

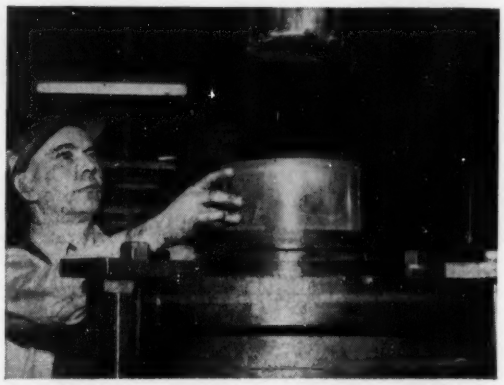
Bonderite and Bonderlube, by more efficient lubrication, help plants reach new production levels, get more efficient and economical production, and achieve better, more uniform quality.

Parker's cold forming experience in many plants and on many products is available to apply on your cold forming problems at once. Write or call today.



Cupping: Flat CO_2 cylinder blank, treated with Bonderite and Bonderlube, is changed into cylindrical form, with maximum of about 45% reduction in diameter of blank.

First reduction: Diameter of cup is made smaller and length increased without major change in wall thickness.



Second reduction: Final diameter of part with respect to length determines number of reductions required. Photos courtesy NORRIS-THERMADOR Corporation, Los Angeles, California.

FREE TECHNICAL BULLETIN MAILED ON REQUEST

Illustrated technical bulletin "Bonderite and Bonderlube As Aids In Cold Forming" contains detailed information. Mailed free on letterhead request.

Since 1914 — leader in the field

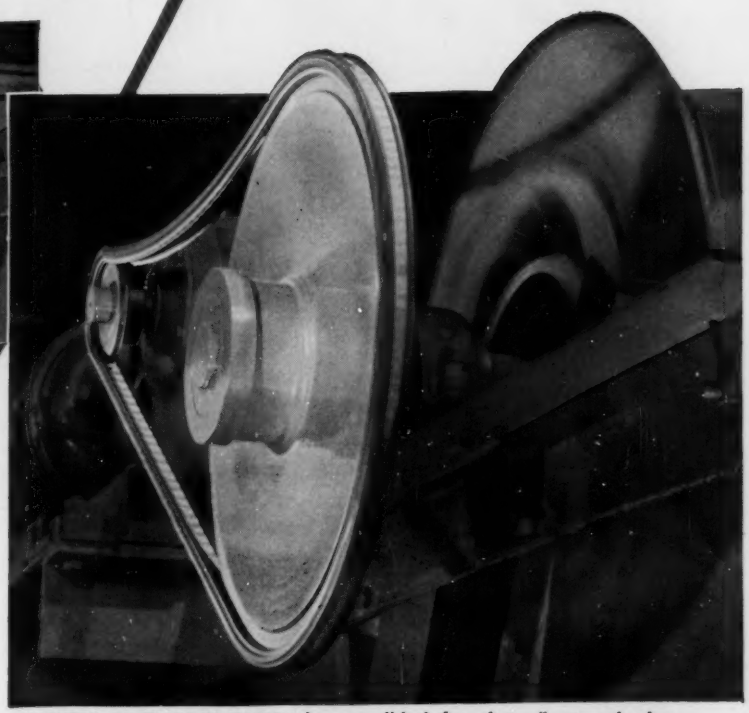
PARKER RUST PROOF COMPANY
2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U.S. Pat. Off.*

It's not just static strength...

RESISTANCE TO TENSILE STRESS is achieved by use of properly heat-treated, accurately-machined side bars made of premium steel and fitted with properly-hardened pins, bushings and rollers. But to resist *operational* stresses, additional controls over dimensional accuracy, uniformity and roller resiliency are essential.



STRENGTH OF CHAIN IN MOTION is accomplished through tensile strength *plus* special Link-Belt refinements. These include pitch-hole preparation, micro-finish of parts, special processing of sidebars, prelubrication and rigid quality control from initial selection of materials to final protective boxing.

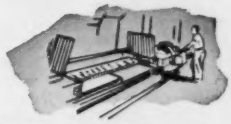
it's *dynamic strength*

in LINK-BELT Roller Chain that fights fatigue

On high-speed, heavy-duty equipment, every roller chain component faces severe operating stresses — engagement with sprockets, shock of starting loads, centrifugal loads and others. That's why *dynamic strength*—ability of chain to resist these stresses—is so important. And it's built into *every length* of Link-Belt Precision Steel Roller Chain through special design, manufacturing and processing steps —providing required properties of uniformity and accuracy for long-life operation.

Ask for Book 2457, covering this complete line of single and multiple widths, in ¼ to 3-inch standard pitch, 1 to 3-inch double pitch. 14.277

LINK-BELT gives you dynamic strength that comes from these important EXTRAS



PRE-STRESSING of multiple width chain provides uniform load distribution.

SHOT-PEENED ROLLERS have greater fatigue life, added ability to withstand impact.

LOCK-TYPE BUSHINGS (applied on a range of sizes) end a cause of stiff chain.

LINK-BELT

ROLLER CHAINS & SPROCKETS

Looking for the BEST chain and sprockets for a specific need? LINK-BELT makes the complete line

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

The "O" Rings you want are RIGHT HERE

This ultra-modern plant supplies—in volume—"O" rings with outstanding performance advantages. VIX-SYN rings are supplied in standard compounds covering a wide range of needs. If your problem requires a special compound because of heat, pressure or fluid conditions, we will work with you either to select one already available or to develop the type needed.

STOCK APLENTY

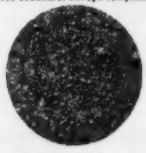
There's no such thing as a production emergency if Houghton is your "O" ring source. Adequate stocks of standard sizes are maintained. Should your production line be caught short, a phone call will speed the "O" rings you need on their way to you.

Houghton's super-dense VIX-SYN rubber formula is the key to long "O" ring life

Cross-section of average compound

Coarser, less dense pattern of rubber is indicated in this photomicrograph of a standard packing compound, magnified 240 diameters. Note lack of uniformity.

Cross-section of Vix-Syn compound



Fine-grain density of rubber throughout Houghton Vix-Syn packing is shown in this cross-section similarly magnified. This compact, homogeneous quality means longer packing life.

Houghton Vix-Syn plant

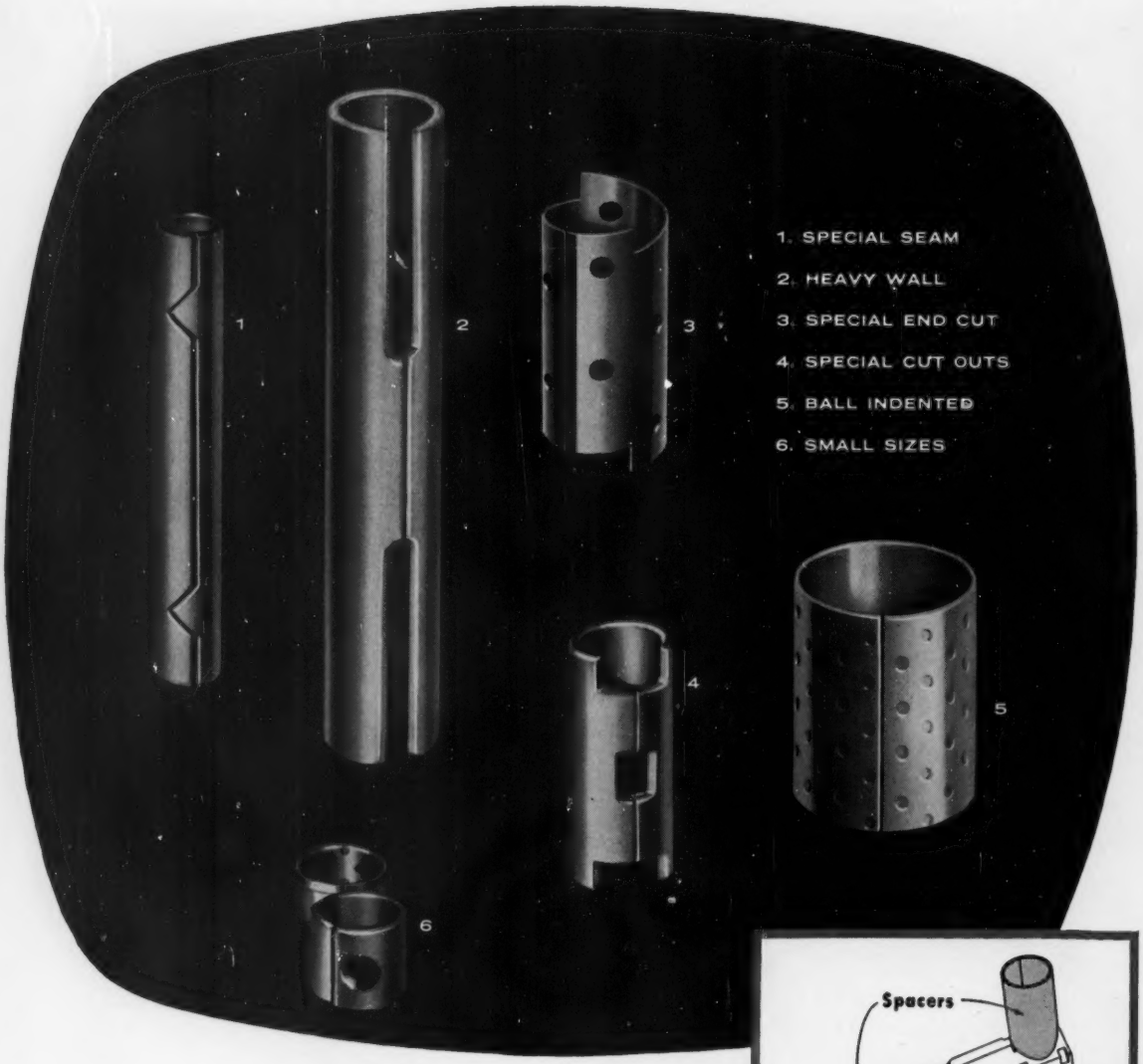
Houghton VIX-SYN Synthetic Rubber is also available in "V's", "U"-cups and special shapes and in a variety of compounds and durometer readings. Vim leather back-up washers specifically designed for use with "O" rings, and fabricated rubber packings, are also supplied. Ask your Houghton Man for latest bulletin, or write to E. F. Houghton & Co., 303 W. Lehigh Ave., Phila. 33, Pa.

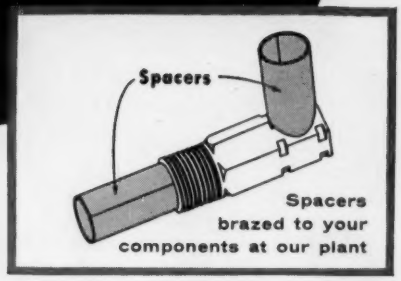
products of . . . E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

Circle 463 on page 19





Spacer tubes save time and money for their users

In these rolled steel spacer tubes we can offer you infinite design variations, to do a multitude of industrial jobs, at attractive costs. They are furnished ready for immediate assembly, to your exact dimensions. They eliminate costly cut-off and deburring. They are a money-saving substitute for iron pipe, tubing or mechanical parts, reduce raw material handling, scrap and inventory. They can be copper-brazed to your other components. Now used in hundreds of automotive, appliance, farm implement, wheel goods and other applications. Complete engineering service. Write for free catalog.

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FEDERAL-MOGUL DIVISION

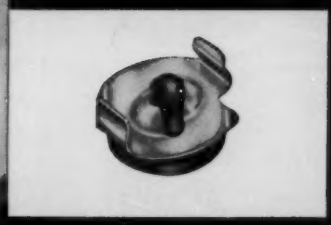
FEDERAL-MOGUL-BOWER BEARINGS, INC., 11045 SHOEMAKER, DETROIT 13, MICHIGAN

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

Circle 464 on page 19

DOT THREAD CUTTING FASTENER
HOLDS TIGHT TO CURVED SURFACES

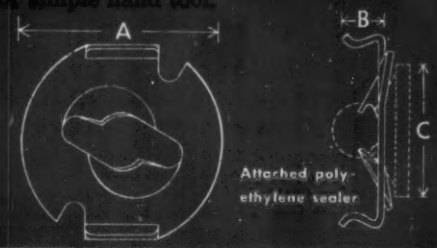
- Low Cost
- Re-Usable
- Self-Locking
- Vibration-Proof
- Spring Take-Up



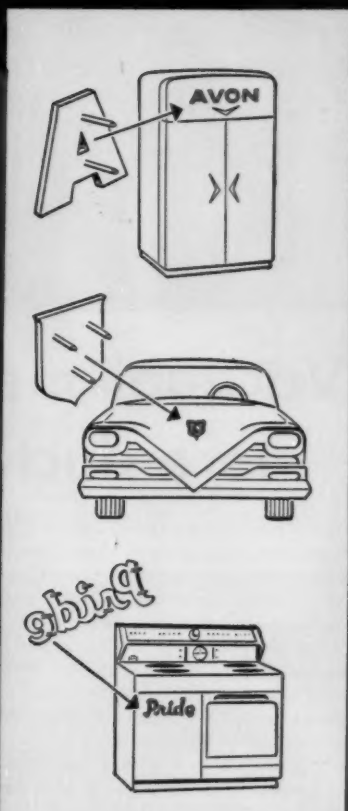
Specially designed to hold die-cast or coid-forged name plates, emblems and trim against sheet metal surfaces . . . DOT'S unique T.C.F. can be used in many other applications which require a spring take-up fastener that pulls up tight without backup on flat or contoured surfaces.

It cuts clean, deep threads on unthreaded studs, even those that are chrome plated. When used with its preassembled plastic sealer, T.C.F. makes a water-tight seal. The sealer *precedes* the fastener onto the stud so that it is not damaged by the thread-cutting process.

Available *in quantity*, with or without sealer, to fit 1/8" and 3/16" studs. Drawings available on request for magnetic tool or simple hand tool.



Nominal Sizes	A	B	C	D	E	F	Driving Torque	Ultimate Strength
1/8"	.560	.170	.450	6° / 4°	.095 .085	.130 .125	7-10 Inch lbs.	200 lbs.
3/16"	.705	.200	.450	6° / 3°	.160 .150	.192 .184	20 - 30 Inch lbs.	400 lbs.



Manufactured by
MONADNOCK MILLS SUBSIDIARY
San Leandro, Cal.

DOT T.C.F.
Patent Pending

Manufactured by
CARR FASTENER CO. DIVISION
Cambridge, Mass.

UNITED-CARR FASTENER CORPORATION

Circle 465 on page 19

Vacuum-melted alloys stay stronger more ductile at high temperatures

Where engine temperatures exceed 1200°F, for example, vacuum-melted alloys add high strength without loss of ductility. Reason? In vacuum-melting, metals of unprecedented composition control and purity are standard. Inclusions are almost totally absent; mechanical and physical properties are higher and more uniform in all directions, and also from heat to heat. Furthermore, many alloys are readily made under the precise control of vacuum melting that are otherwise impossible or uneconomical to make at all.

Vacuum Metals Corporation, Division of Crucible Steel Company of America, is the first and largest producer of vacuum-melted metals. It is now melting heats up to 3000 pounds. Large sections and a wide variety of alloys are available to the aircraft industry. We would like to work with you on metals problems which vacuum-melted alloys may solve. Please write, giving as much detail as possible, to *Vacuum Metals Corporation, Division of Crucible Steel Company of America, P. O. Box 977, Syracuse 1, N. Y.*

Vacuum-melting is adding new performance to these metals. Do you have an application that may benefit from their use?

- High temperature alloys
- Bearing steels
- Tool steels
- High strength alloy steels
- Low alloy steels for springs
- Stainless steels
- Hard facing alloys
- Electronic alloys
- Nuclear reactor materials
- Special nonferrous alloys
- Alloys for investment castings

VMC®

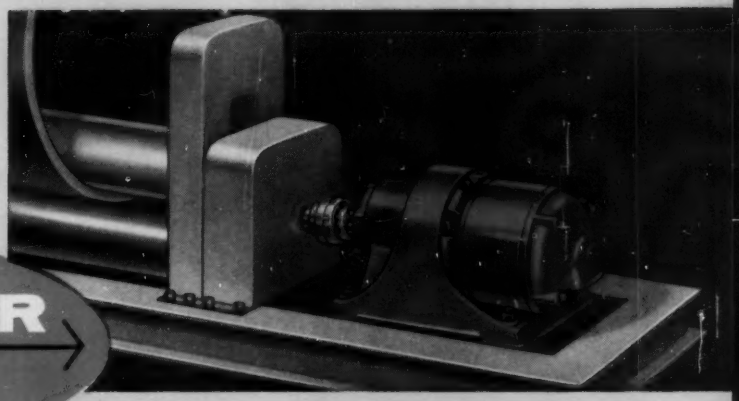
VACUUM METALS CORPORATION

Division of Crucible Steel Company of America

Circle 466 on page 19

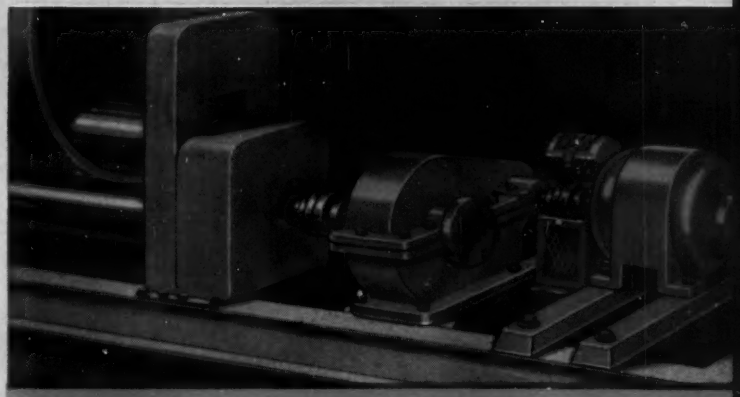
Circle 467 on page 19→

USE THE *Simplest* METHOD TO APPLY LOW SPEED POWER



SYNCROGEAR
THE INTERNALLY GEARED MOTOR

Reject CUMBERSOME HOOKUPS



The U. S. Syncrogear is more than a motor. Its "packaged" assembly includes a high speed motor, an enclosed sealed gear-train, correctly engineered for the load, always in exact alignment, all mounted in a single case which saves space and eliminates the ungainly appearance of complicated hookups. You don't have to calculate chain, sprocket, bearing or shaft requirements, or invest in separate mechanisms, special fabricated guards, extra pulleys and belting when you direct-connect a Syncrogear. More and more manufacturers are using Syncrogears on their products to improve appearance and increase saleability.

Free – Mail coupon for all new descriptive multicolor booklet with all the facts you should know about geared motors.

U.S. *Electrical* MOTORS

MAIL COUPON NOW ▶

U. S. ELECTRICAL MOTORS Inc.
P. O. Box 2058, Los Angeles 54, Calif., or Milford, Conn. MD-

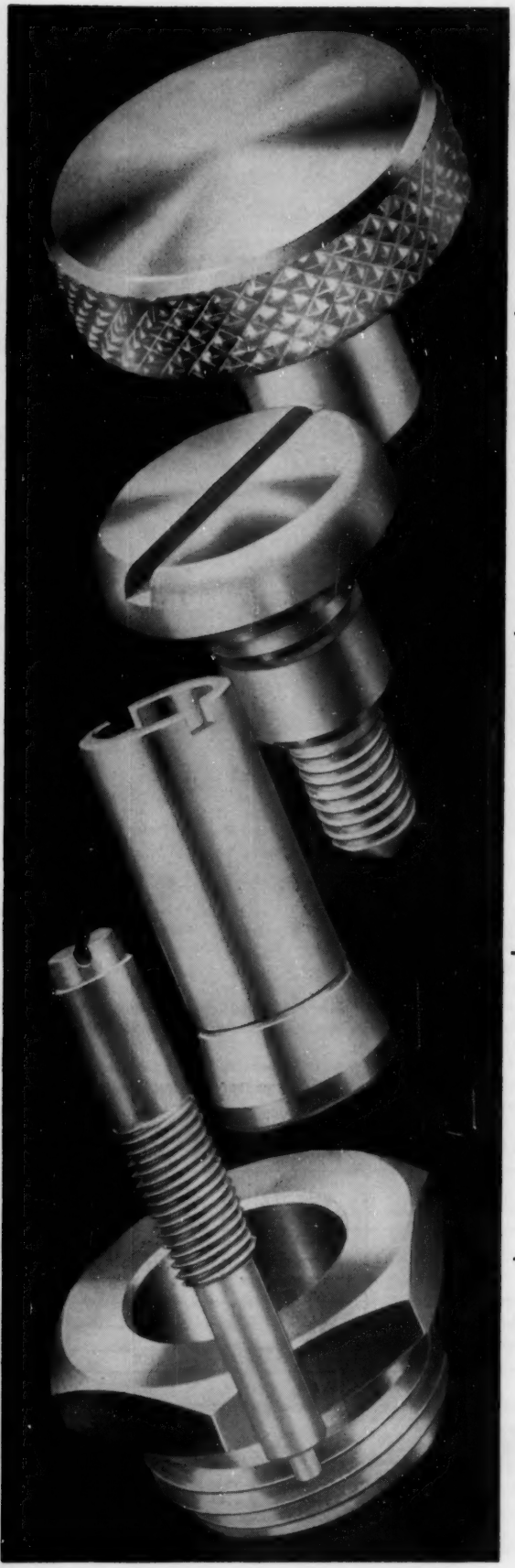
☐ Send Syncrogear Booklet

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____



Adjusting Knob
for Room Thermostat

Cost per 1,000 parts:

Brass	$16.10
Aluminum	9.44
Savings	$ 6.66
Percent Savings	41.3%

Cover Screw
for "Protecto Relay" Unit

Cost per 1,000 parts:

Brass	$16.80
Aluminum	10.80
Savings	$ 6.00
Percent Savings	35.7%

Tension Nut
for "Immersion Aquastat"

Cost per 1,000 parts:

Brass	$9.10
Aluminum	4.50
Savings	$4.60
Percent Savings	50.5%

Adjusting Screw
for "Immersion Aquastat"

Cost per 1,000 parts:

Brass	$11.90
Aluminum	7.33
Savings	$ 4.57
Percent Savings	38.5%

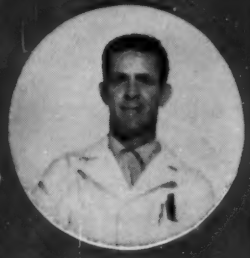
Packing Nut
for Temperature Controller Unit

Cost per 1,000 parts:

Brass	$33.60
Aluminum	21.45
Savings	$12.15
Percent Savings	36.2%

Recommended by Managements

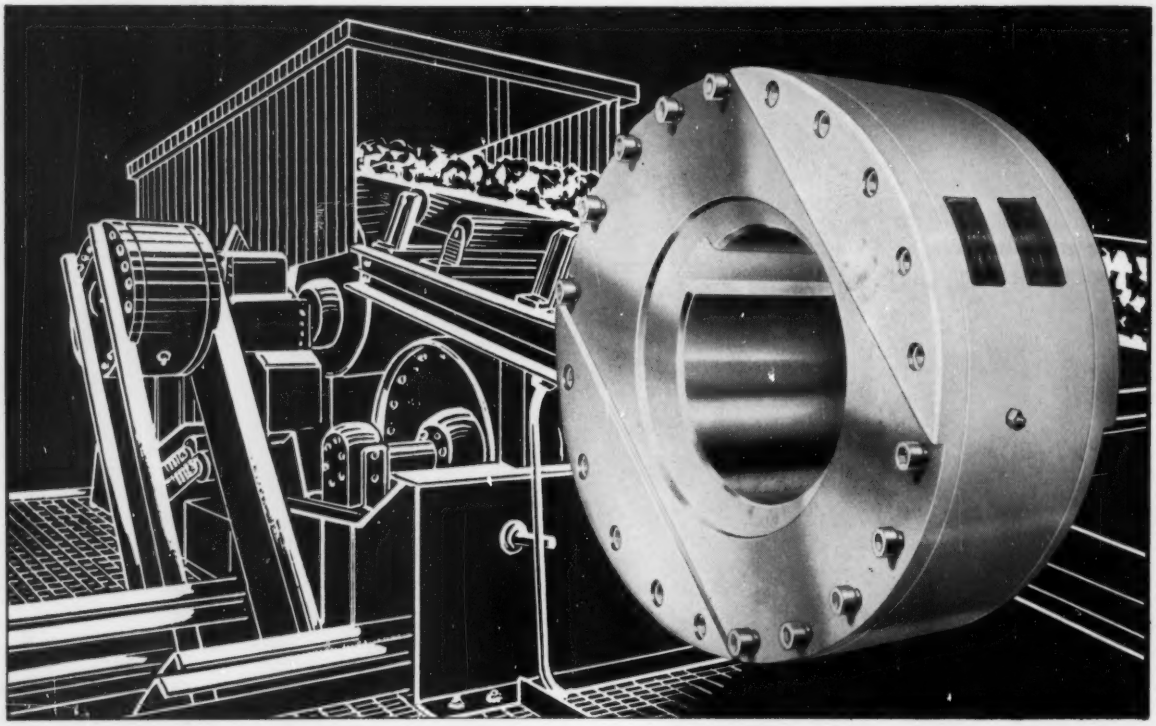
Specified by Designers



Preferred by Operators

Circle 468 on page 19

136,500 Ft.-Lbs. of Holdback Torque



New Heavy-Duty Design

FORMSPRAG *"Positive Action"* BACKSTOPS

Here, at last: Positive protection from hazardous reverse torque-runaway. Thorough-going tests on all major makes of inclined conveyor and elevator equipment have proven Formsprag Large Bore Backstops guard both your personnel and your machinery against dangerous and damaging "runback".

No more runback worry from conveyors stalled because of overload or power failure. You're now fully protected. What's more, you stop reverse torque at its source, the headshaft. So, maintenance headaches caused by many present inadequate reverse torque controls are minimized.

All Formsprag Large Bore Backstops employ the modern sprag-type clutch principle—proven so successful on a wide range of over-running and indexing applications. This guarantees you these important advantages:

Greatest torque capacity to weight ratio. Ball-bearing construction for longer life and smooth over-running. Mechanical seals to prevent entry of abrasives. Individually energized spring-loaded sprags. Grease lube is required only twice yearly.

Next time you have a power transmission application on an inclined conveyor or elevator, protect yourself, specify Formsprag.

FOR MORE INFORMATION . . .

Write today! This new 26 page catalog will be sent immediately.

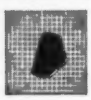
CHECK THESE CAPACITIES

MODEL NO.	MAXIMUM OVER-RUNNING SPEED RPM	TORQUE CAPACITY LB. FT.	APPROXIMATE WEIGHT LBS.
FS-1100	185	18500	350
FS-1150	170	24000	450
FS-1200	140	36000	650
FS-1250	130	51500	1000
FS-1300	115	73000	1250
FS-1400	100	136500	2200

Over-Running, Indexing and Backstopping Clutches for aircraft, automotive and various industrial applications

FORMSPRAG COMPANY

VISIT BOOTH 208
Design Engineering Show, May 20-23



23603 HOOVER ROAD • VAN DYKE (DETROIT), MICHIGAN

World's largest exclusive manufacturer of over-running clutches

Distributors in principal cities

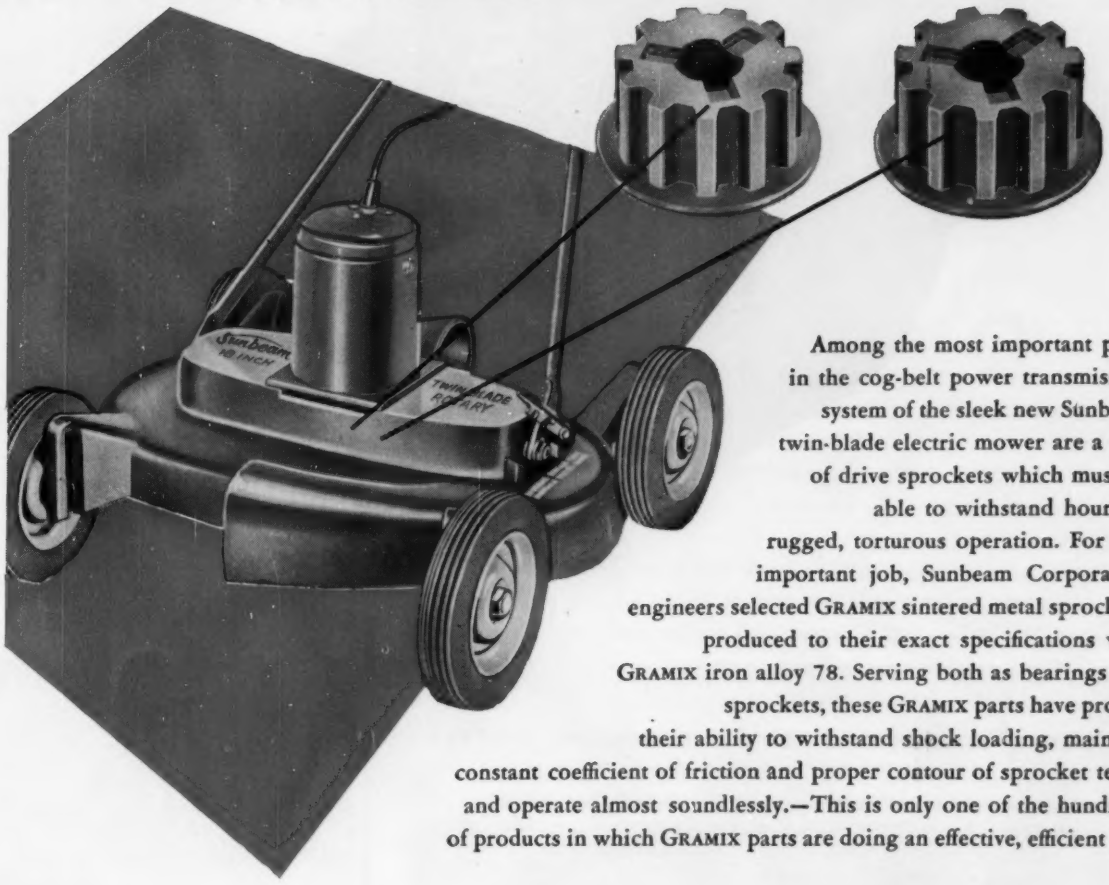
A6-4C

for their new electrical mower

Sunbeam engineers specify long wearing

GRAMIX® iron sprockets

(PRODUCT OF POWDER METALLURGY)



Among the most important parts in the cog-belt power transmission system of the sleek new Sunbeam twin-blade electric mower are a pair of drive sprockets which must be able to withstand hours of rugged, torturous operation. For this important job, Sunbeam Corporation engineers selected GRAMIX sintered metal sprockets, produced to their exact specifications with GRAMIX iron alloy 78. Serving both as bearings and sprockets, these GRAMIX parts have proved their ability to withstand shock loading, maintain constant coefficient of friction and proper contour of sprocket teeth, and operate almost soundlessly.—This is only one of the hundreds of products in which GRAMIX parts are doing an effective, efficient job.

Write for this book. Being die-pressed to shape, then sintered, GRAMIX parts usually cost less than machined pieces . . . yet can be produced to tolerances as close as .0005 inch. GRAMIX Bulletin No. 21 tells the whole story. Write today for your copy.

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® • SINTERED METAL PARTS MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

Circle 470 on page 19

NEW

THESE 4 FEATURES MAKE NEW R & M ARMATURES OUTSTANDING

■

All coils are wound simultaneously. Coils are exactly identical, assuring identical electrical and physical characteristics. Conventional methods produce windings with individual coils having varying amounts of wire and consequent non-symmetry.

■

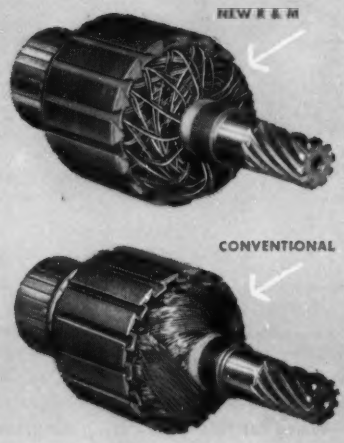
Armature coils are uniformly positioned and anchored securely. Interlocked winding pattern resists conductor and coil end movement. This unique construction minimizes abrasion of wire insulation, a common cause of high speed armature failure.

■

Maximum coil end exposure resulting from distinctive winding pattern permits maximum heat dissipation. Lower temperatures prolong armature life.

■

More uniform electrical characteristics reduce arcing at brushes, improving commutation and prolonging brush life.



ROBBINS & MYERS, INC.

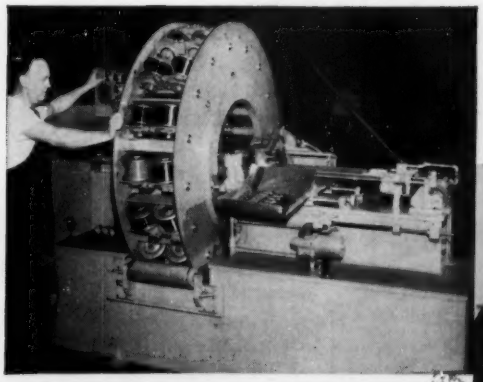
SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

R & M PRECISION MACHINE-WOUND ARMATURES

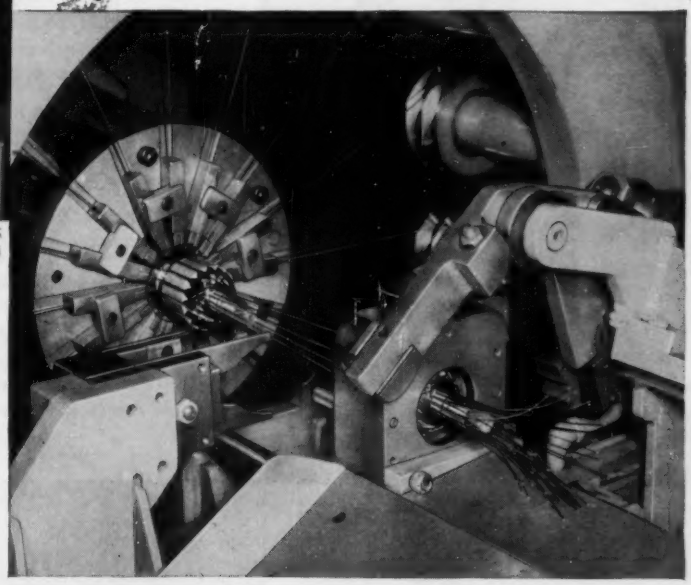
can improve your product's performance!

A new basic development in armature winding technique, perfected by Robbins & Myers, now produces armatures for Universal or Series Motors which are superior to those heretofore available for original equipment manufacturing. The new R & M armature winding machine winds all coils simultaneously . . . uniformly positions them . . . and the coils are physically and electrically identical! Weaknesses inherent in armatures wound by conventional methods are eliminated. The new R & M machine produces armatures of finer, more uniform construction which will give longer, more dependable service!

Contact a Robbins & Myers representative for additional details on R & M universal motors and series motor parts or write for Bulletins 444-MD and 455-MD.

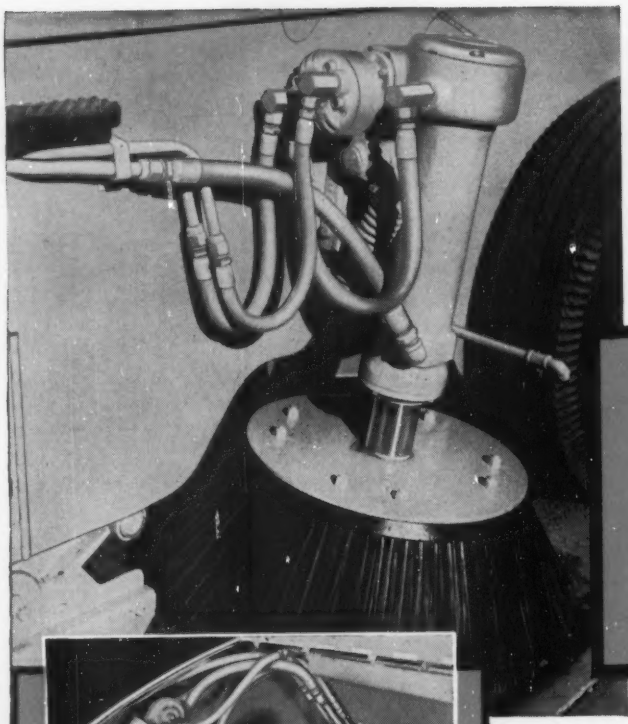


AUTOMATION AT R & M SPEEDS ARMATURE WINDING AND IMPROVES ELECTRICAL AND PHYSICAL QUALITIES OF PRODUCT.



R&M®

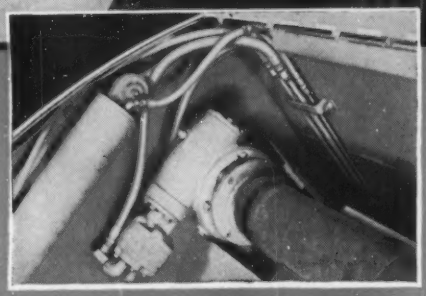
Circle 471 on page 19



THREE HYDRAULIC CONTROLS INCREASE BROOM LIFE:

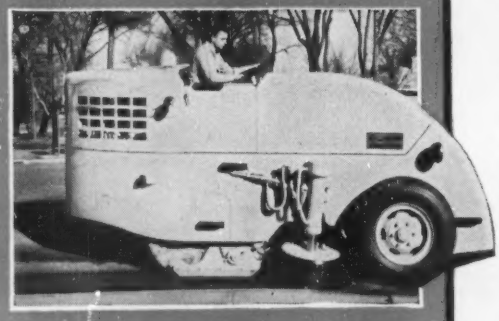
1. Constant sweeping pressure maintained hydraulically with "floating" pressure, which compensates for any street irregularities.
2. Relief valve protects mechanism from curb damage.
3. Snubbing action eliminates bounce and undue wear to the broom.

HYDRAULICS IMPROVE SWEEPER PERFORMANCE



Two hydraulic circuits are used at maximum pressure of 1250 psi., supplied by direct driven pumps independent of vehicle drive.

Conveyor belt is driven hydraulically. Main broom floats under hydraulic pressure, with one lever controlling broom rotation, activating automatic belt training and conveyor belt rotation. Double acting hydraulic cylinders also open and close hopper.



Eastman—Elgin Engineering Staff Cooperate to Improve Efficiency and Service . . . Cut Manufacturing Costs

When Elgin Sweepers were converted to hydraulics, Elgin engineers enlisted the cooperation of Eastman engineers in the pilot application of Eastman Hydraulic Hose Assemblies.

The result of Elgin's conversion to hydraulics was more than an improvement in operating performance and efficiency—it resulted in space-saving economies which permitted dramatic improvements in streamlined design—as well as reduced manufacturing and maintenance costs.

Again, as in many instances in the past . . . Elgin, who pioneered the first successfully marketed sweeper in 1912 . . . turned to Eastman—who pioneered in the very first applications of Hydraulic Hose Assemblies. LEACH PACKMASTER, an associate Elgin product, is also an original Eastman user.

We invite you to write if you have a hydraulic conversion problem. We urge you to call upon our more than 40 years of experience—unequalled in the industry. Take advantage of our many original designs and advanced construction features. Enjoy the sales prestige of Eastman Hydraulic Hose Assemblies—*Standard of the Industry!*

Eastman
first in the field

MANUFACTURING COMPANY
DEPT. MD-4, MANITOWOC, WIS.

Circle 472 on page 19

NOW

a new STEAM valve with all the Rockwood Ball Valve advantages!

The new Rockwood Bronze Ball Valve for use with steam offers you many unusual benefits.

It Handles up to 125 Pounds of Steam per square inch and 350°F, with ease.

It's Leakproof — even after continued use Rockwood Steam Ball Valves stay dry.

It Opens and Closes Quickly—only a quarter turn is needed to open or close Rockwood Ball Valves.

It Has Longer Wear-Resistance — chrome-plated bronze ball withstands abrasion, scratching and pitting.

Rockwood's new Ball Valve for use with steam comes in pipe sizes from ⅜" up to 2". Send coupon for full information and data. Distributors in all principal industrial areas.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
1231 Harlow Street
Worcester 5, Mass.

Send me illustrated folder on Rockwood's new Ball Valve for use with steam.

Name.....

Title.....

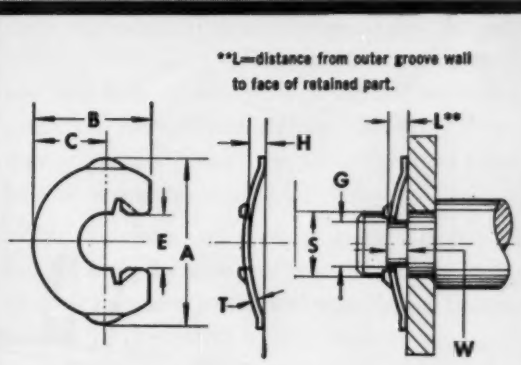
Company.....

City.....Zone..State.....

Circle 473 on page 19

New Waldes Truarc locking-prong ring functions as spring, shoulder, fastener... and STAYS PUT!

Above assembly shows how 2 Waldes Truarc Locking-Prong Rings (Series 5139) replaced 6 parts... eliminated threading operation... and need for skilled labor.



WALDES TRUARC LOCKING-PRONG RING (Series 5139)
U. S. Pat. Pending

Ring No. 5139–	SHAFT Dia. S	SHAFT tol.	RING DIMENSIONS A	tol.	B	tol.	C	tol.	E	tol.	H	tol.	T†	tol.†	average ultimate shear strength lbs.*	GROOVE DIMENSIONS Dia. G	tol.	Width W	tol. −.000	L min.	L max.	resilient end play take up L max.−L min
12	.125	±.002	.340	±.010	.307	±.010	.166	±.005	.086	±.004	.050	±.010	.010	±.0013	400	.082	±.0015	.045	+.005	.035	.045	.010
★15	.156	±.003	.380	±.010	.330	±.010	.184	±.005	.108	±.004	.055	±.010	.010	±.0013	600	.104	±.002	.050	+.005	.035	.045	.010
18	.188	±.003	.445	±.010	.390	±.010	.213	±.005	.130	±.005	.060	±.010	.015	±.0015	900	.124	±.002	.065	+.005	.045	.055	.010
25	.250	±.003	.581	±.010	.500	±.010	.280	±.005	.172	±.005	.070	±.010	.015	±.0015	1000	.165	±.002	.070	+.005	.050	.065	.015
31	.312	±.003	.744	±.010	.620	±.010	.360	±.005	.234	±.005	.095	±.010	.018	+.001 −.002	1300	.228	±.003	.080	+.005	.080	.095	.015
★37	.375	±.003	.853	±.015	.740	±.010	.427	±.005	.280	±.005	.130	±.010	.020	±.002	1900	.270	±.003	.105	+.005	.090	.115	.025
★43	.438	±.003	.960	±.020	.820	±.020	.475	±.010	.337	±.010	.130	±.010	.020	±.002	2200	.327	±.003	.105	+.005	.095	.120	.025

Additional Sizes Under Development ★Production dies not available as of date of printing †Applies to unplated rings only *Recommended safety factor =3 to 4.

The Waldes Truarc Locking-Prong Retaining Ring is a new, low cost, radially applied fastener which can be locked positively in its groove and used as a shoulder against rotating parts. It is primarily intended for use in the automotive, electronic and aeronautical industries.

This radially applied ring locks positively in its grooves by means of two prongs at the open end. Because of its high thrust-load capacity the Waldes Truarc Locking-Prong Ring may be used as a shoulder against rotating parts. Its bowed construction provides for end-play take-up in the assembly and makes less critical the tolerances required for the parts being fastened. Since it serves as a spring as well as a shoulder, this ring eliminates the need for springs, washers, and other accessory fastening devices.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

SEND FOR FREE SAMPLES

WALDES TRUARC® RETAINING RINGS

Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C. 1, N.Y.

☐ Please send me sample Locking-Prong Rings. (please specify shaft size_____)

☐ Please send me supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.

(Please print)

Name_____

Title_____

Company_____

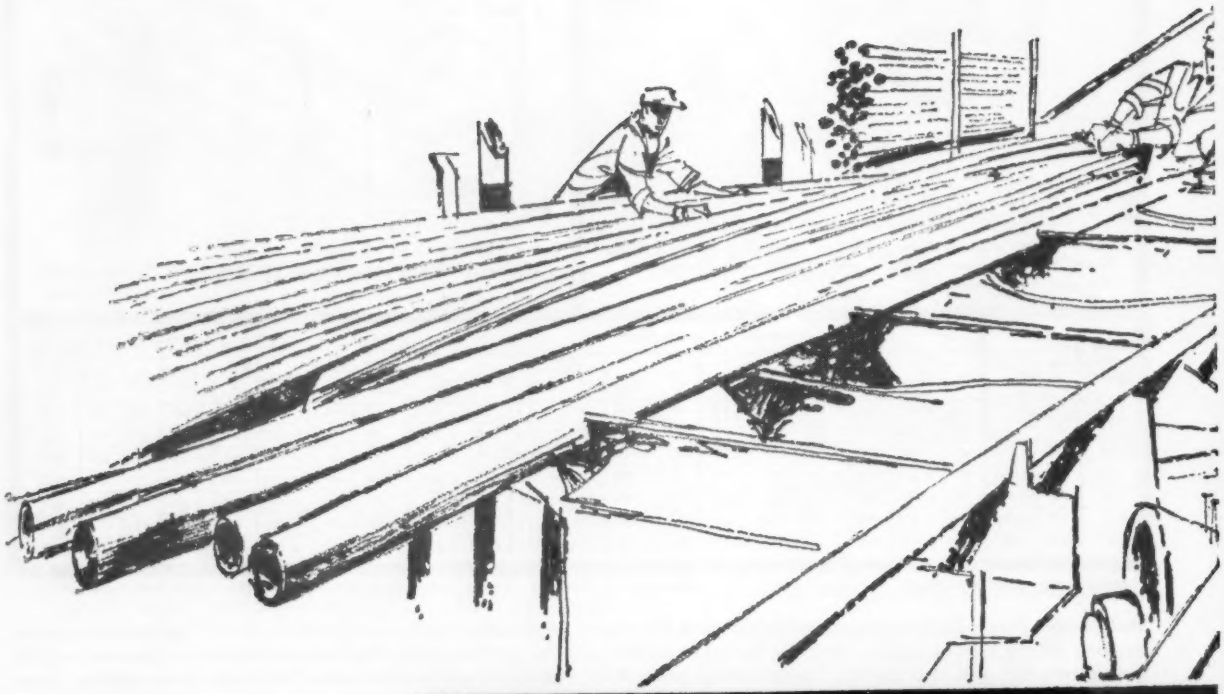
Business Address_____

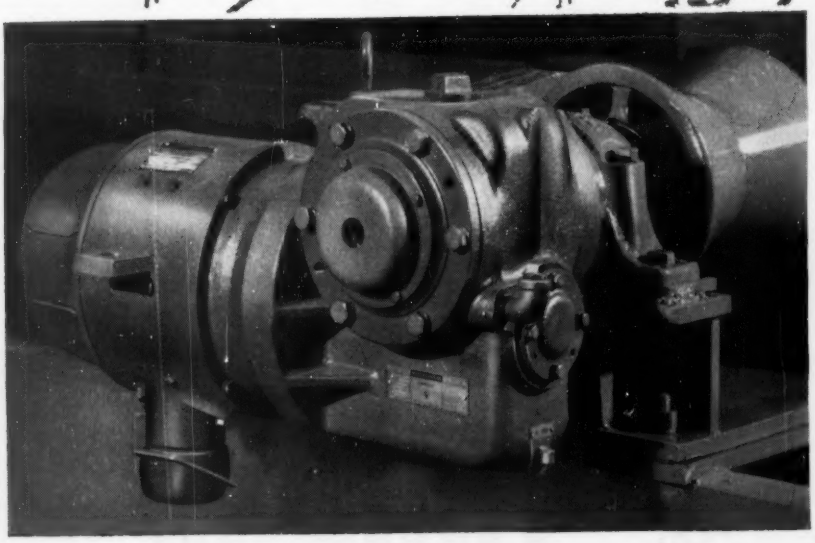
City_____ Zone_____ State_____

MD 049

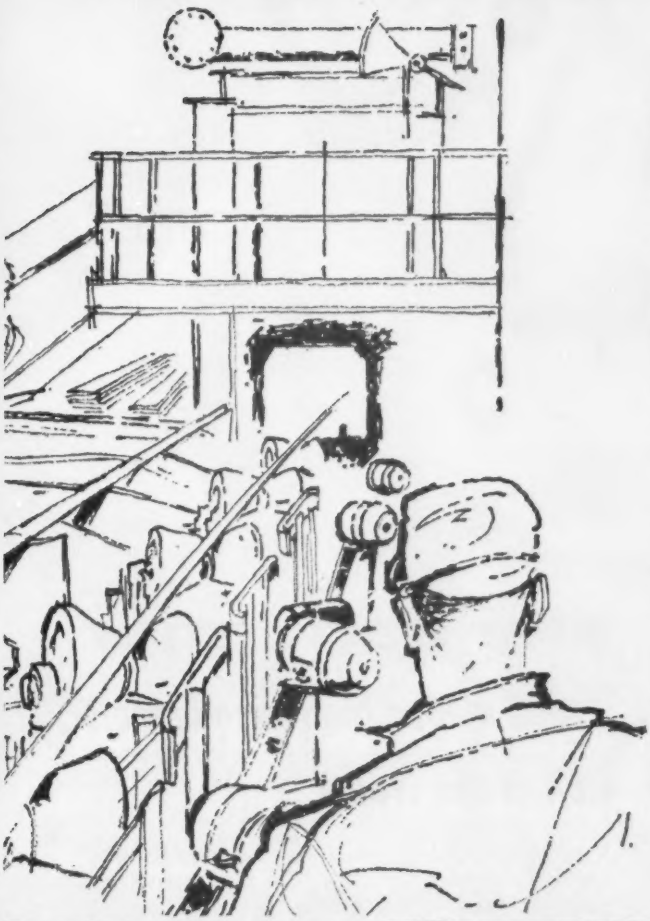
WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

Seamless tube delivery gets **Triple protection in**





Westinghouse floating gearmotors

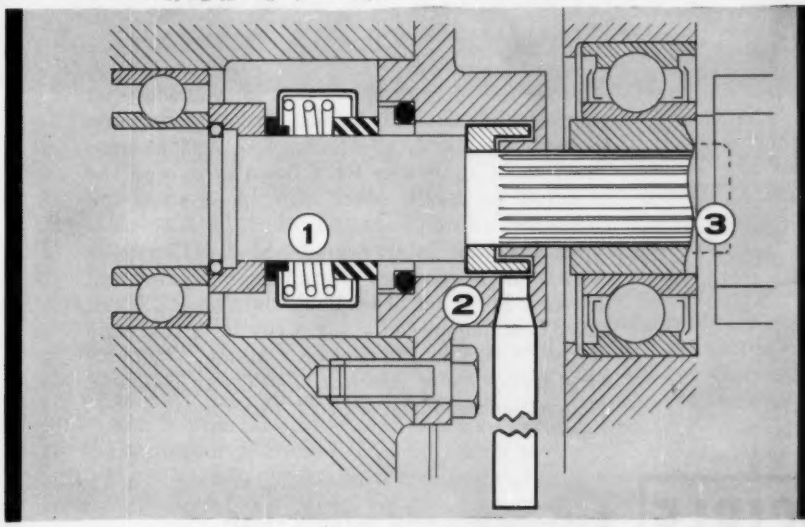


Westinghouse floating shaft gearmotors have undergone the critical tests of 24-hour-a-day, run-out table operations. Typical results come from a seamless tube drawing, tempering and annealing operation. Here, Westinghouse units bring three-way protection against the always-present problems of oil leakage and motor changes.

Two separate seal systems guard against oil leaking from the gear unit into the motor. An indicating feature warns of seal wear, before failure, in time for preventive maintenance.

Westinghouse splined shaft coupling permits easy separation of motor and gear assembly in seconds. Valuable inspection time is saved and motor changes can be made on the job, reducing down time.

Shock-absorbing spring mounting and rugged construction make Westinghouse floating-shaft gearmotors extremely tough . . . but why not see for yourself in Booklet B-6370. Call your local Westinghouse sales engineer for a copy, or write Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pa. J-07354



1. A combination labyrinth-packing and face-type seal on the pinion shaft prevents oil leakage from the gear housing into the motor.

2. For added protection an umbrella seal and drain catches any leakage through a worn shaft seal. Visual indication of seal wear is given by the drain.

3. The simple spline connection between motor and gear shafts permits fast demounting of the motor without disturbing gears or bearings.

YOU CAN BE SURE...IF IT'S Westinghouse

star performer

...and among high speed steels

REX is the leader

Crucible REX® high speed steel has been the winner in shop tests for more than fifty years. *And now REX is even better than ever!* For Crucible research and experience has led to improved manufacturing techniques that mean higher quality – greater uniformity.

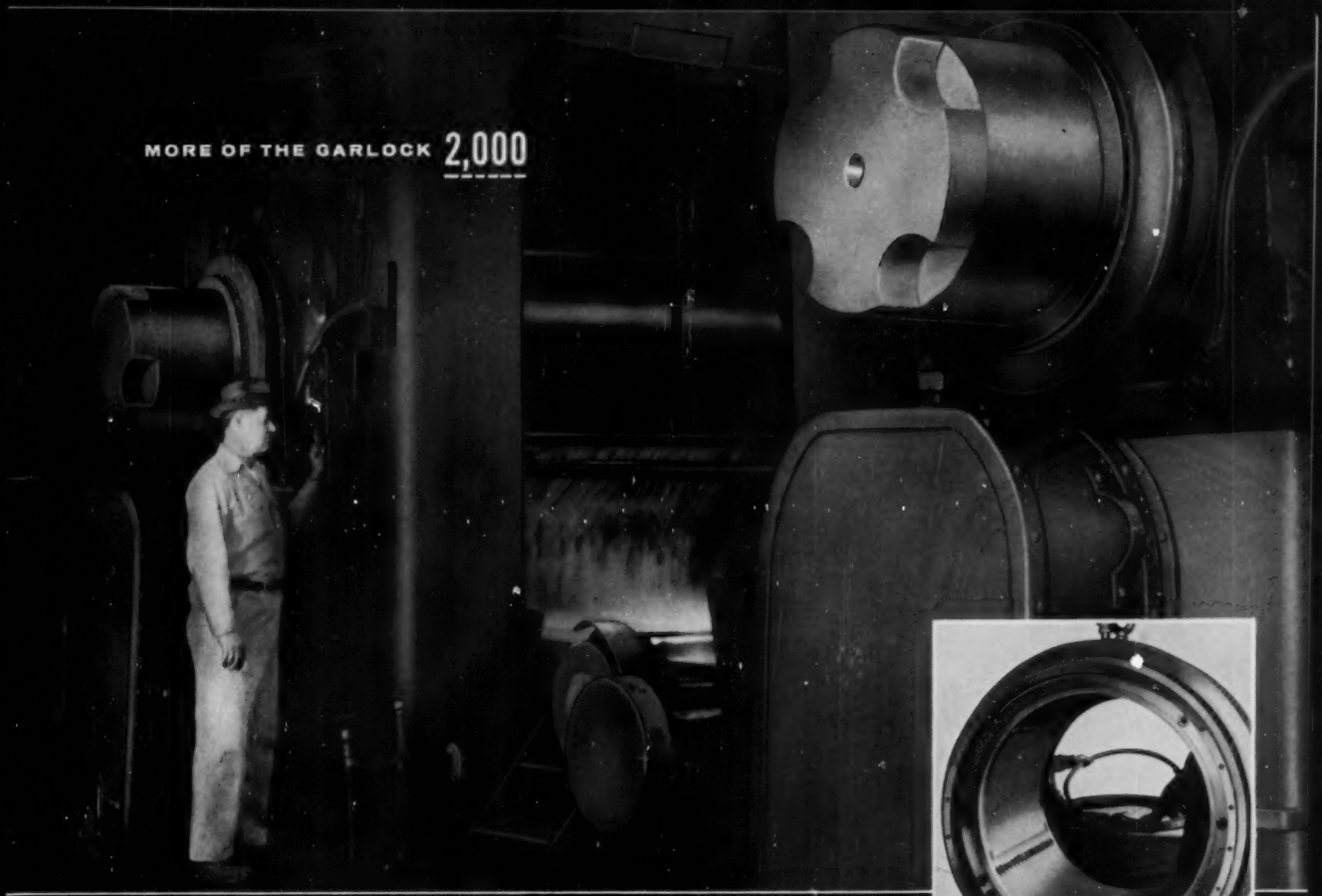
Prove the superiority of REX for yourself – on your next job. Check it for size, structure, response to heat treatment, all-around tool performance. Then you'll know why REX has always been the *standard by which other high speed steels are compared.*

REX is immediately available at all of Crucible's convenient warehouses – or through prompt mill delivery. For a list of available data on REX and other Crucible *special steels*, write for a free copy of the "Crucible Publication Catalog". *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

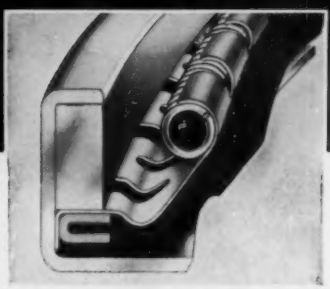
Crucible Steel Company of America

Canadian Distributor — Railway & Power Engineering Corp., Ltd.



YOUNGSTOWN Equips Hot Strip Mills with Garlock KLOZURE* Oil Seals . . . SAVES OIL and MAINTENANCE TIME

Photo shows roll bearing in foreground with KLOZURE Oil Seal and retainer ring removed. In background a new KLOZURE Oil Seal is quickly inserted in retainer ring.



Cross section of Model 64 KLOZURE Oil Seals used on back-up rolls of steel mills.

Nine back-up rolls on the Hot Strip Mill illustrated have been equipped by Youngstown Sheet & Tube Company with 72 Garlock KLOZURE Oil Seals. The rolls run at speeds of 1025 ft. per min. Oil pressure is approximately 8 psi. at temperatures to 120° F.

Youngstown is able to roll a half a million tons of steel on this Mill before the KLOZURE Oil Seals need replacement. Furthermore, considerable maintenance time is saved when replacement seals are applied.

Also, a large percentage of oil has been saved due to the application of Garlock KLOZURE Oil Seals.

If you have an application that requires oil seals, why not investigate the advantages of KLOZURE Oil Seals. They are another important part of "the Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals for every need. It's the only complete line . . . that's why you get unbiased recommendations from your Garlock representative. Call him or write for KLOZURE Catalog.

THE GARLOCK PACKING COMPANY, Palmyra, New York

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

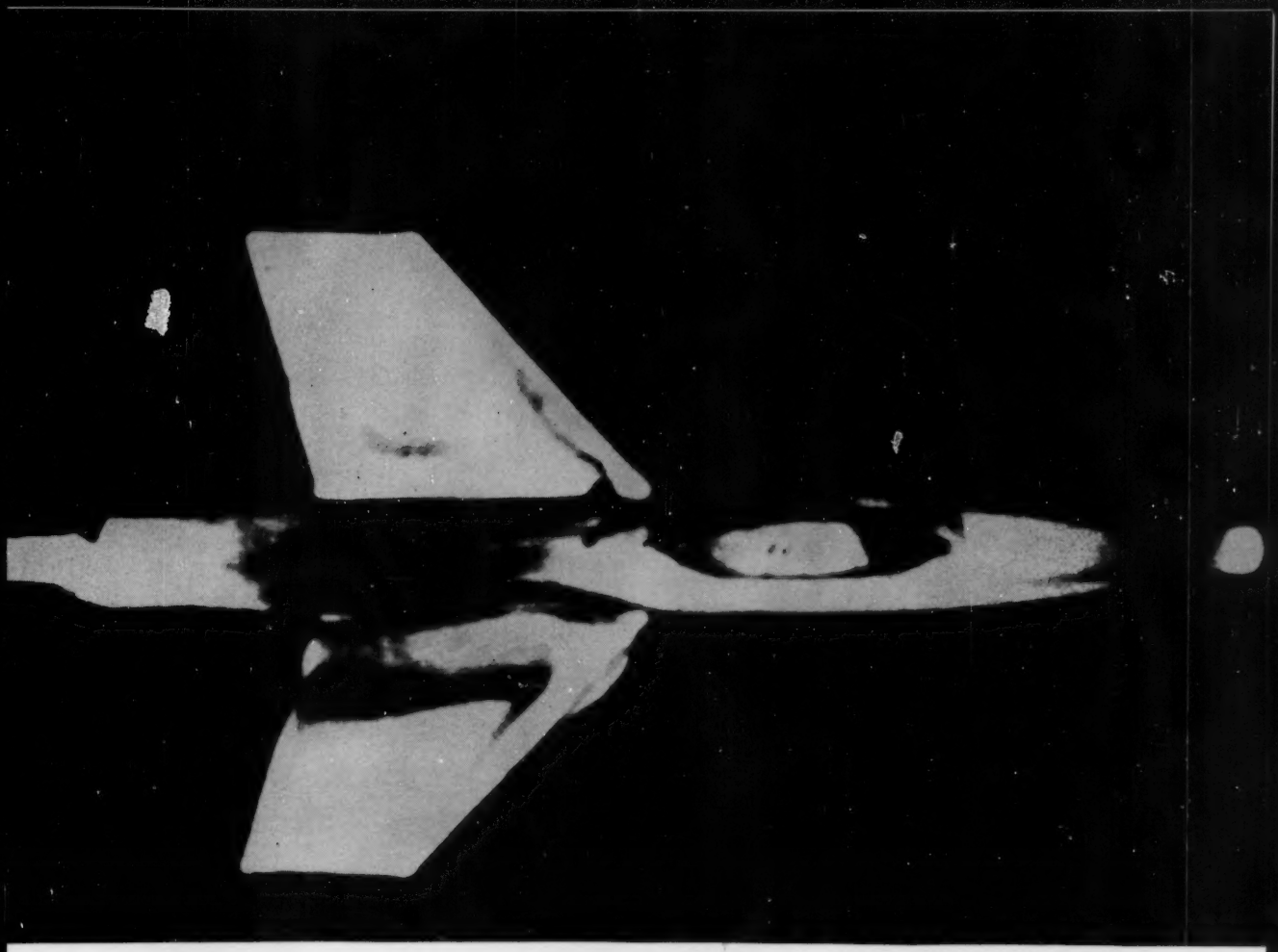
**Registered Trademark*

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

Circle 478 on page 19

Circle 478 on page 19



thermal thicket

The thermal barrier which now limits the speed of ultra high speed aircraft can be cracked. Needed: Structural components of elevated temperature alloys. Problems: Finding the right alloys; making them easy to forge and machine with regular production-line tools; maintaining uniformity of physical properties in production lots.

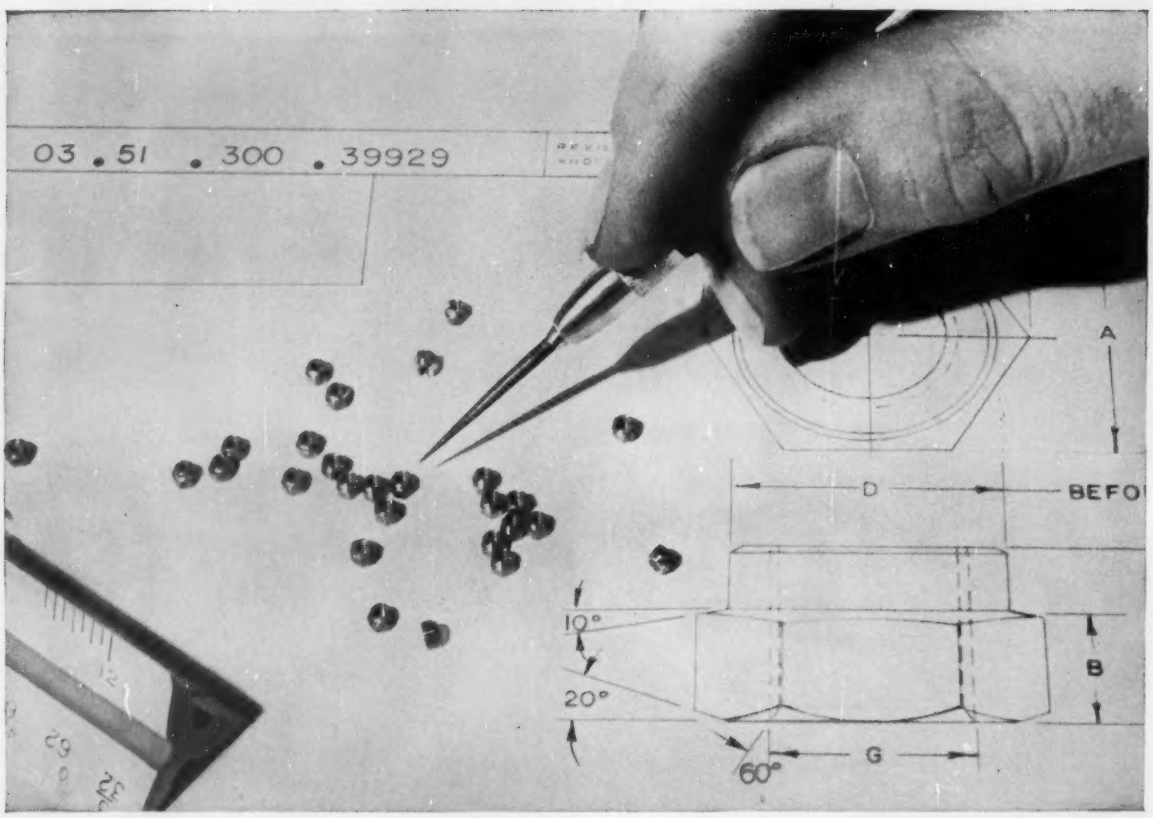
Right now, Carpenter is producing elevated temperature alloys which set new standards for consistent ability to meet tough aircraft specifications, high quality, improved forgeability and machinability. Engine builders find them ideal for many critical parts. Forge shops can work them to closer tolerances, get better finishes that require far less than usual machining. Work goes faster. Rejects are fewer.

You can get the full story of these alloys — their application, fabrication and engineering properties — in the new booklet, "Carpenter Alloys for Elevated Temperature Service". Get your personal copy by writing on your Company letterhead. The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.

Carpenter STEEL

Improved alloys for elevated temperature service

Circle 480 on page 19



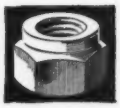
FLEXLOC MICROSIZE locknuts meet designers' needs for tiny precision nuts that retain strength and holding power in the smallest assemblies—servomechanisms, electronic and electrical equipment, all miniature devices.

New FLEXLOC Microsize Locknuts

Now available in Alloy Steel, Stainless Steel, Brass and Aluminum for lighter, more compact designs

SIZE	Across Flats		Hex. Height	Across Corners	Height
	MAX.	MIN.	REF.	MIN.	REF.
0-80 NF-3B	.111	.107	.046	.121	.075
1-64 NC-3B	.127	.123	.056	.140	.090
1-72 NF-3B	.127	.123	.056	.140	.090
2-56 NC-3B	.158	.153	.067	.176	.105
2-64 NF-3B	.158	.153	.067	.176	.105
3-48 NC-3B	.190	.183	.071	.210	.120
3-56 NF-3B	.190	.183	.071	.210	.120
4-40 NC-3B	.190	.183	.071	.210	.120
4-48 NF-3B	.190	.183	.071	.210	.120

SPECIFICATIONS: Available in brass (plain or cadmium plated) and aluminum (plain or chemically treated), for temperatures to 250°F; in alloy steel (plain or cadmium plated) and 18-8 stainless steel (silver plated) for temperatures to 550°F.



New FLEXLOC Microsize locknuts are smaller and lighter than regular FLEXLOCS of the same nominal diameter. Wrenches of smaller size are used to install them. Mating joints or flanges can be designed smaller—with no loss in strength or convenience of assembly.

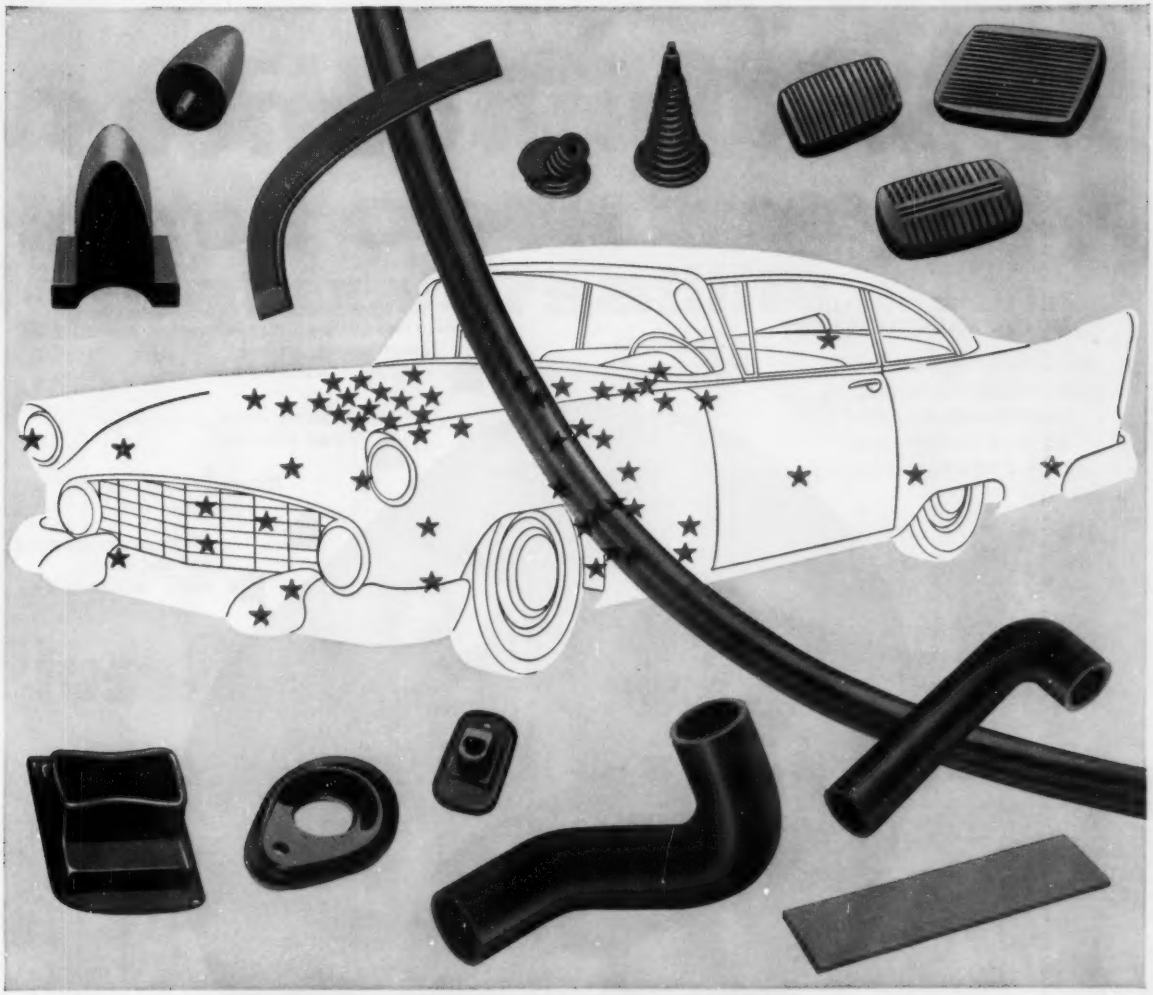
Microsize FLEXLOCS have all the advantages of larger FLEXLOCS. One-piece, all-metal construction—nothing to put together, come apart, lose or forget. Use them as lock or stop nuts—they stay put anywhere on a threaded member as soon as the locking threads are fully engaged. Uniform locking torques insure accurate preloading. There are no nonmetallic inserts to pop out or deteriorate. Moisture, dryness, oil won't affect these Microsize FLEXLOCS. Just screw them on. They lock and stay locked. Vibration won't shake them loose.

For complete information on Microsize FLEXLOCS, consult your authorized SPS distributor. Or write STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

STANDARD PRESSED STEEL CO.

FLEXLOC LOCKNUT DIVISION SPS

JENKINTOWN PENNSYLVANIA



★ some of the more than 100 places where ENJAY BUTYL works, silently and dependably, helping to improve the performance of today's new cars.

ENJAY BUTYL—fabulous all-weather rubber BOOSTS PERFORMANCE IN '57 CARS

Molded into more than 100 parts, this super-durable, all-weather rubber helps provide a steadier, softer, more silent ride under even the most strenuous conditions of stress, weather change, and abrasive action. The dependability of all these parts contributes to the outstanding performance of the modern car.

Readily available in non-staining grades, Enjay Butyl rubber can be compounded into white and light-colored parts that combine beauty with top-notch performance. Low in cost, it out-performs and out-lasts all other rubbers formerly used, and may well be able to *cut costs* and *improve performance* in *your* product. For further information, and for expert technical assistance, contact the Enjay Company.

ENJAY BUTYL

Enjay Butyl is the greatest rubber value in the world . . . the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y

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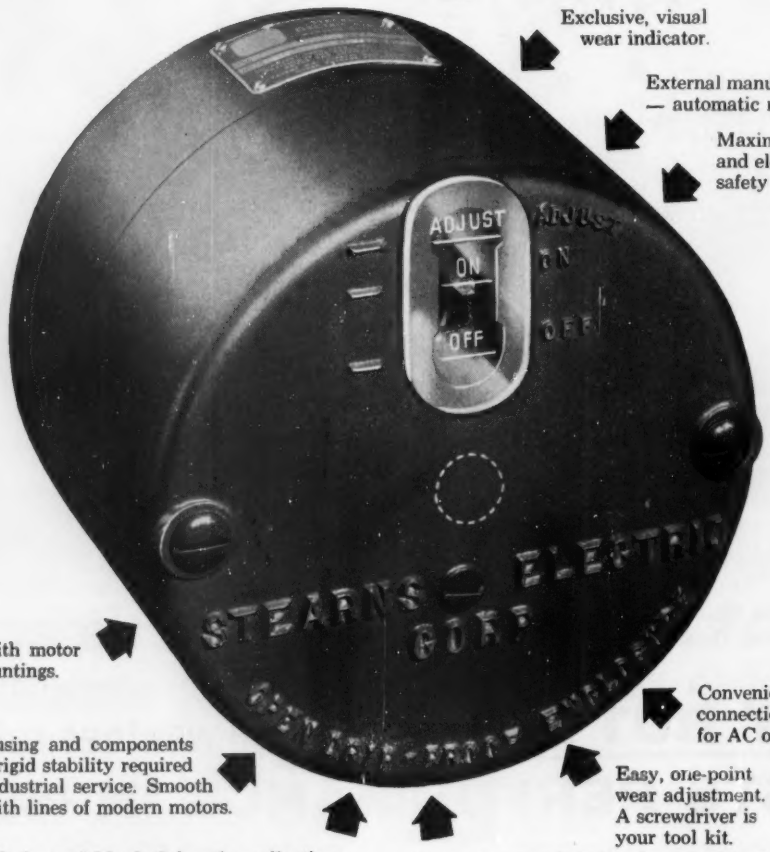
Circle 482 on page 19

Stearns announces New HT-70 Series

THE CHOICE OF LEADING MOTOR MANUFACTURERS



Positive spring-set action for fast, smooth stops. Brake sets automatically in event of power failure. Instantaneous, no-drag, single solenoid release.

Exclusive, visual wear indicator.

External manual release — automatic reset.

Maximum mechanical and electrical safety factors.

Available with motor or floor mountings.

Rugged, cast housing and components for strength and rigid stability required for long, hard industrial service. Smooth contours blend with lines of modern motors.

Adaptable for variable shaft length applications. Can be used for straight through-shafts. We'll supply the hole in the housing if required.

Famous Stearns ball bearing, single solenoid construction for smooth action, trouble-free life.

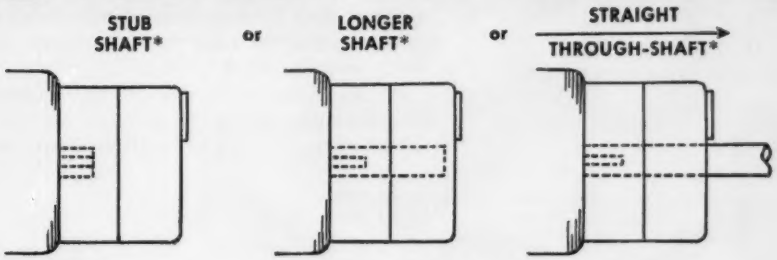
Easy, one-point wear adjustment. A screwdriver is your tool kit.

Convenient electrical connections. Available for AC or DC operation.

When you use one of these new HT-70's with "Any-Shaft" design, the shaft can extend right through the brake so that you can drive off both ends of the motor, and still take advantage of fast, smooth stops . . . instant, no-drag, single solenoid release. Use of HT-70's will also afford you a new, complete flexibility in your replacement motor stocking program . . . no special shafts. Note that these new HT-70's have all the rugged simplicity . . . the tough, trouble-free qualities . . . the same easy, single-point adjustment and maintenance of all their predecessors. HT-70 housings can be supplied drilled for through-shaft operation, or you can easily do it yourself, as the housing comes off quickly with removal of just two screws.

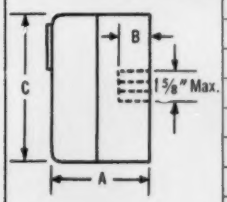
Circle 483 on page 19

a NEW electro-magnetic BRAKE
-faster, easier installation
-greater versatility



Use the HT-70 Series with "Any-Shaft" length... drive from both ends of motor... eases replacement motor stocking problems.

Plus
1. *"Any-Shaft" design
2. Complete range of sizes from 10 to 105 lb ft torque.

HT-70 Series For Motor Mounting**	Max. Torque lbs ft.	Size No. Type(-9)*	"A" O.A. Length	"B" Sugstd. Min.	"C" O.D.	Shipping Wt. lbs
	10	HT-72-9	6½"	1⅝"	8¾"	33½
	15	HT-72A-9	6½"	1⅝"		34
	25	HT-72B-9	6½"	1⅝"		34
	35	HT-72C-9	7½"	1⅝"		38
	50	HT-74-9	7"	1¹³⁄₁₆"		38
	70	HT-74A-9	8"	1¹³⁄₁₆"		42
	75	HT-76-9	7⅜"	2¹⁄₁₆"		45
	105	HT-76A-9	8⅜"	2¹⁄₁₆"		47

* (-9) For new motor frame sizes 213 thru 256U with new NEMA "C" end shields
** Also available for floor mounting

Max. Torque lbs ft.	Size No. Type (-11)*	"A" O.A. Length	"B" Sugstd. Min.	"C" O.D.	Shipping Wt. lbs
10	HT-72-11	6⅜"	1⅜"	10⅜"	35½
15	HT-72A-11	6⅜"	1⅜"		36½
25	HT-72B-11	6⅜"	1⅜"		36½
35	HT-72C-11	7⅜"	1⅜"		42
50	HT-74-11	6⅞"	1¹³⁄₁₆"		47
70	HT-74A-11	7⅞"	1¹³⁄₁₆"		51
75	HT-76-11	7⅜"	2¹⁄₁₆"		53
105	HT-76A-11	8⅜"	2¹⁄₁₆"		55

* (-11) For new motor frame sizes 284U and 286U with new NEMA "C" end shields

Designed to give a greater range of application, more flexibility, the HT-70 Series is but one example, one small group of over 150 sizes and types of standard Stearns electro-magnetic disc brakes available to fit rerated NEMA motor frames in sizes ranging from 1/20 to 100 hp, AC or DC operation.

Maximum torque ratings are available ranging from 0.6 to 7,500 lb ft. Vertical, horizontal, motor or floor mountings are available in most types. Brakes are available in most sizes with explosion-proof, or dust and waterproof enclosures. Special or marine fiinishes are available.

For complete electro-magnetic brake, clutch, or combination clutch-brake data, call your local Stearns representative . . . or mail coupon direct to . . .

20

BRAKES MILWAUKEE Stearns WISCONSIN CLUTCHES

ELECTRIC CORPORATION
120 NORTH BROADWAY • MILWAUKEE 2, WISCONSIN

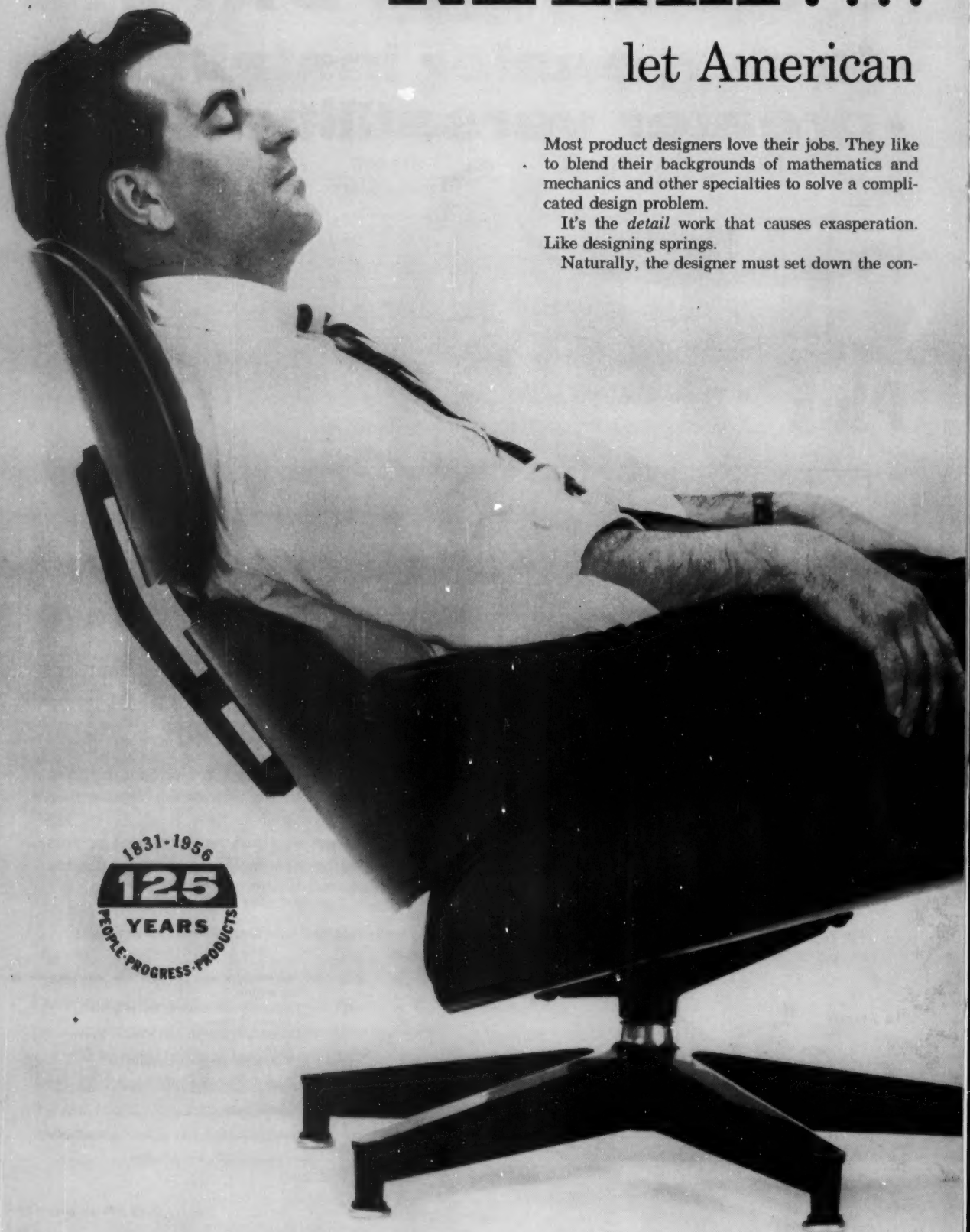
Please send:
- ☐ Further information on HT-70 Series Brakes.
- ☐ Complete Clutch and Clutch-Brake data.
- ☐ Complete Brake Portfolio F

Name _____ Title _____
Company _____
Street _____
City _____ Zone _____ State _____

Circle 484 on page 19→

RELAX!...

let American



Most product designers love their jobs. They like to blend their backgrounds of mathematics and mechanics and other specialties to solve a complicated design problem.

It's the *detail* work that causes exasperation. Like designing springs.

Naturally, the designer must set down the con-

1831-1956
125
YEARS
PEOPLE · PROGRESS · PRODUCTS

when you have a spring problem Steel & Wire worry *for* you

ditions of use. He knows how much stiffness he wants, what fastening system is desirable, the limits of spring travel, corrosion conditions and the like. Now, the plot thickens. Can such a spring be produced, in quantity, at a reasonable price?

It is a rare designer who has concerned himself with these practical spring production problems.

For this reason, American Steel & Wire maintains a staff of *spring engineers* to relieve you of this detail. They may be able to suggest a minor design change, or a different grade of steel, or a different finish that will give you a better spring than you contemplated at a decided savings in cost.

Just call your AS&W salesman.

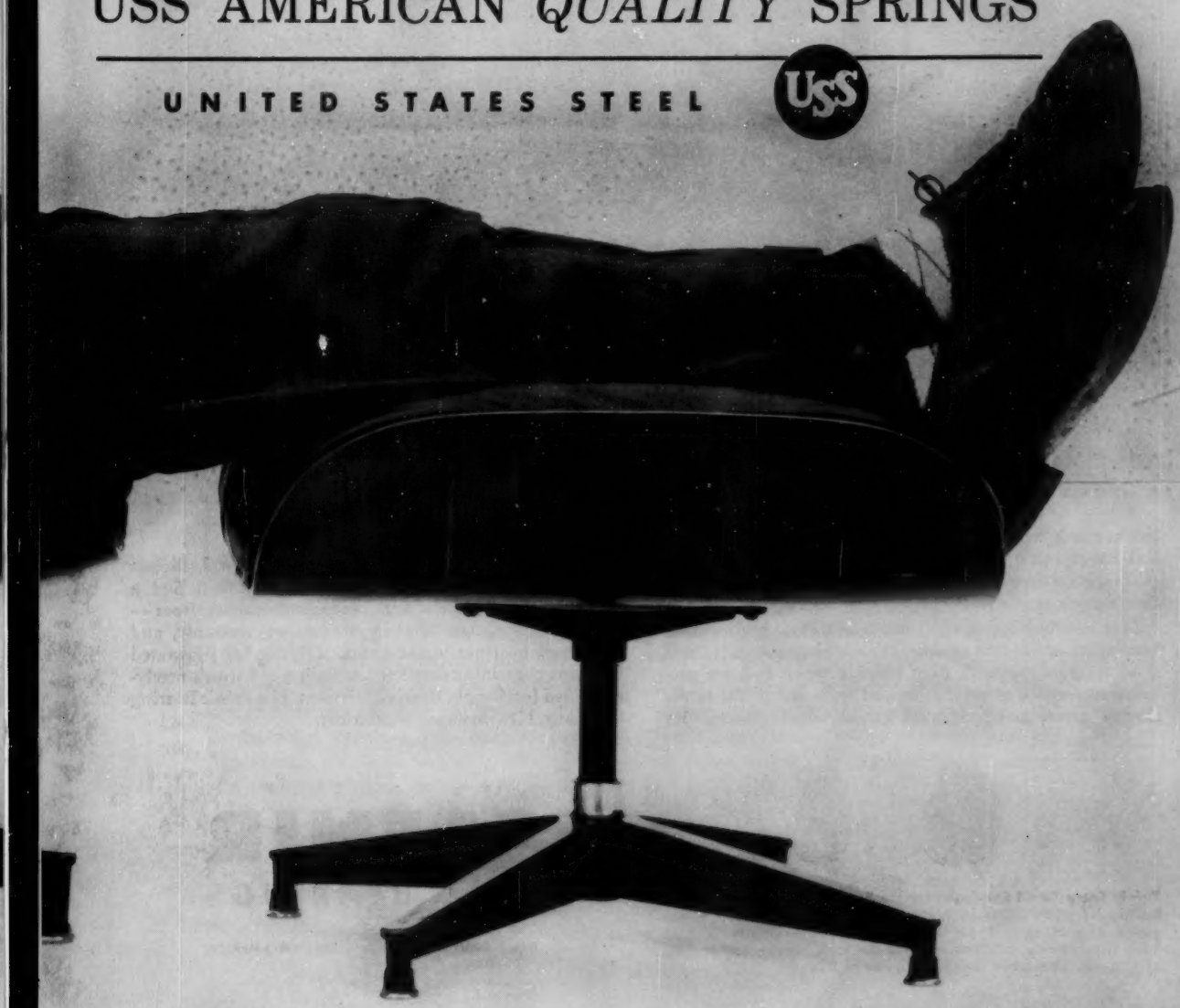
AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL, GENERAL OFFICES: CLEVELAND, OHIO

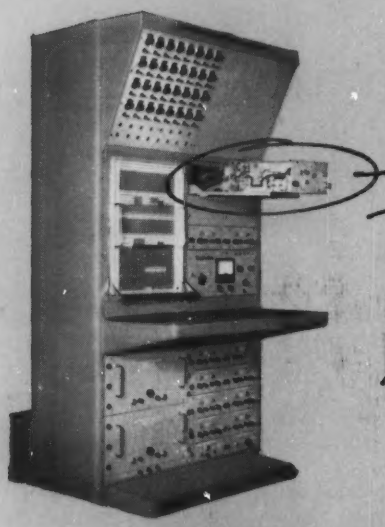
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS · TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS

UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS AMERICAN *QUALITY* SPRINGS

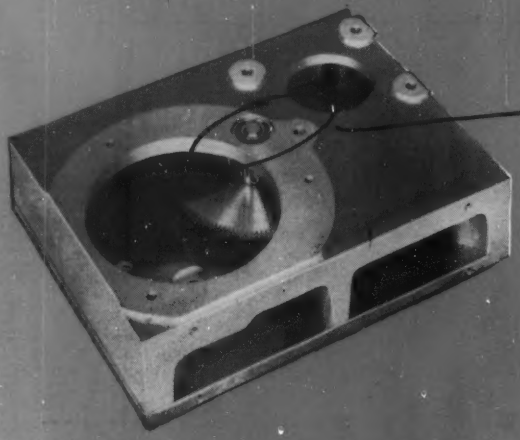
UNITED STATES STEEL USS





Problem:

To assure instant response lasting precision in servo multiplier gear train



Solution:

FAFNIR Precision Instrument Bearings

In Electronic Associates' Analog Computer, instant response and unvarying operational precision of servo multiplier gear trains are a must. Fafnir Extra-Small Special-Precision Bearings are specified for this demanding application.

Precision-finished to exact tolerances, these high-quality bearings provide the sensitivity, running accuracy, and rigid support required. Both bearing types used are prelubricated at the factory. Equipped with shields for retention of grease and protection against contaminants, they keep maintenance at a minimum.

You, too, can count on Fafnir for effective and efficient solutions to precision bearing problems. You'll find a broad line of precision ball bearings to choose from — backed by the most modern production, assembly, and inspection facilities in the industry. Write for illustrated brochure containing detailed description of Fafnir's newly-expanded Instrument Bearing Division. The Fafnir Bearing Company, New Britain, Connecticut.

Fafnir Extra-Small Special-Precision Bearings are used in servo multiplier gear trains in Electronic Associates' Analog Computer. The Flanged Type (at left) features shoulders integral with the bearing to allow straight through boring for perfect alignment. The other is same size but unflanged.

FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

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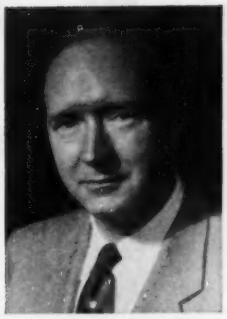


MACHINE DESIGN
APRIL 18, 1957

More Power to You

A CENTURY AGO electricity was a scientific curiosity which scarcely touched the lives of most people. Even engineers, except for a small minority, were not directly concerned with either production or utilization of electrical energy. Little did they realize the impact it would soon have on their work.

Today nuclear energy has hardly progressed beyond the same stage. Developments being reported seem to possess little direct interest to any except a small minority of engineers, such as weapons engineers and powerplant engineers.

But, as with electrical energy today, nuclear energy inevitably will absorb the interests of vast numbers of engineers in both production and utilization. Currently the major effort is in the development of suitable reactors, and comparatively few engineers are so employed.

The fission process has been extensively researched and the principles and potentials are beginning to be understood. But the engineering of equipment to put it to practical use has lagged. When nuclear reactors get over their growing pains and become as well established as conventional power sources now are, utilization of the products of reactors will assume major importance.

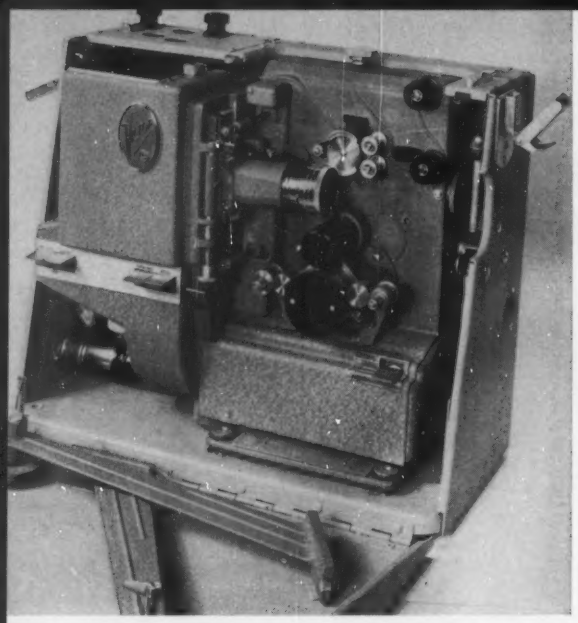
A nuclear reactor is much more than a new type of furnace. It is an amazingly versatile source of heat and radiation, both of which have enormous potential in the design of new machines and equipment. Between the hundred million degrees of the atomic bomb and the few hundred degrees of the submarine propulsion reactor lie all sorts of potential applications such as space ship propulsion, high-temperature metallurgy, process heating, aircraft propulsion and even building heating.

On the other hand, the high-energy radiation from a reactor is capable of creating new elements and radioisotopes with unique properties that could form the basis of a host of new products. These new materials, for example, could be used as nuclear batteries, compact powerplants, or sources of radiation for sterilization, radiography, static elimination, food irradiation, engineering research tools, and medical equipment and appliances, to mention only a few.

The new machines, equipment and appliances that will be designed around these concepts, and others not yet dreamed of, will present challenging opportunities to design engineers. It is not impossible that atomic energy and its products will, in much less than another century, occupy as large a part in engineering thinking as electricity does today.

Colin Carmichael

EDITOR



Case History—Movie Projector

Project

1. Redesign projector to eliminate uncomfortably high operating temperatures in and around lamp housing, and to achieve better arrangement of controls for easier operation.
2. Improve appearance at no increase in cost, size or weight.
3. Design new lamp-housing assembly to be interchangeable with the old to minimize inventory problems.

Procedure

1. Previous models test operated by DfI engineers. Temperatures at various points on lamp-housing recorded to establish range of operating temperatures and exact location of "hot spots."
2. Series of design studies made to arrive at a design which would lower the temperatures.
3. Engineering analysis determined best design to provide a practical solution to temperature problem. At the same time, a simplified, "clean" arrangement with convenient control locations obtained.
4. Unit styled for attractive appearance and increased sales appeal. Design submitted for client approval.
5. Selected design analyzed and modifications made as dictated by cost requirements.
6. Functional test model built to prove that proposed redesign of unit would actually lower operating temperatures.
7. Functional model tested, and engineering changes made in manufacturing drawings.
8. Pre-production prototype, built to final manufacturing drawings, tested to see that it met all client specifications.

Results

1. Redesign of lamp housing reduced exterior temperature from maximum of 400 F on previous model to maximum of 180 F on redesigned model, thus eliminating danger of injury to operator.
2. Appearance of unit improved and other specifications of project successfully met.
3. Manufacturing drawings, prepared to client's standards, used by client for subsequent production.

Working with

By Archer W. Richards
General Manager
Designers for Industry Inc.
Cleveland, Ohio

ENGINEERING design and styling constitute major factors of competition. An innovation, properly timed and executed, is the most effective form of competitive versatility. New-product research should completely re-examine the thinking behind product design, searching for the completely new, rather than merely refining the existing. Present day business demands new ideas, imagination and flexibility of creative engineering action.

This dynamic approach to new products or diversified products may well mean exploring totally unfamiliar fields of product development. In any case, the exploration, fact finding, creating, designing, building and testing of a new product will require fresh creative thinking, qualified personnel, and the necessary facilities, time, and investment.

Product Development Problems

When management considers a new product, it is immediately faced with a number of questions:

1. The magnitude of the problem. How big and how pressing is it?
2. If the problem is not solved, what will be the loss?
3. Is an arbitrary move safe without complete investigation?
4. Does the present organization have the overall experience to solve the problem?
5. Are sufficient research and engineering personnel available?
6. If not, how many people and how much equipment must be added to research and testing facilities?
7. What investment will this temporary expansion require and how long will it take to train and equip a research team?
8. If more technical people must be hired, can they be scheduled with subsequent projects?
9. Will the team apply fresh thinking as an independent unit, or will its thinking tend to run parallel to current practice?
10. Would placing the job outside be more economical, both in dollars and time?

The problems connected with major product-research programs frequently lead firms to con-

Outside Engineering Firms

sider the services of an outside engineering firm. If the project involves exploring unfamiliar territory, a preliminary survey of the field may be made by a research organization. This survey should provide sufficient data to enable deciding whether to go ahead with a development project or to abandon it. If the survey indicates favorable potentials, it may be advantageous to consider employing an outside firm for the development program. Some of the points that may influence management to decide in favor of the outside firm are given separately under *Advantages of the Outside Firm.*

Defining the Objectives

The first step in any development program is to determine exactly what is desired. These objectives and specific parameters of the problem must be clearly defined and understood by all concerned. Poorly defined objectives or expectations can cause expensive and unnecessary confusion in the conduct of the project. Determining the precise objectives should be done whether the program is to be conducted within the company or placed outside. If a new product is contemplated, it will mean a survey of competitive products, market analysis, sales potential, production investment, etc. Once the work to be done has been established, a decision can be made whether to employ outside help for all or part of the project or to utilize the firm's established departments. If this decision favors outside assistance, the proj-

Engineering Service Organizations

Types	Forms
Management	Individual
Engineering Design	Partnership
Process	Corporation
Industrial Design	University
Research	Governmental
Testing	Nonprofit
Market Research	

Advantages of Outside Firm

1. Specialists may be secured for a phase of design or for a complete design. They need not be taken on the payroll for a short-term program. Results can be secured faster than personnel can be assembled and trained by using an established organization.

2. By utilizing the equipment available at an independent organization, capital equipment need not be purchased for problems not of a continuing nature. In effect, the equipment and facilities of the research organization are rented.

3. The technical manpower problem under peak load conditions is solved. In most organizations, the fluctuations of manpower requirements depend on marketing.

4. Use of an independent research organization permits complete control over both the design itself and the investment required.

5. By utilizing independent research, isolation from day-to-day production worries is guaranteed. In the research division, considerable interruption of effort may take place when production problems arise. This interruption not only delays a long-term development program, but may cause more serious damage because of the interruption of thought and loss of personnel. Using the outside firms permits schedules despite project pileups.

6. Independent research organizations are experienced in the handling of a variety of projects. They are not at a loss when an unusual program is presented or when exploring an unfamiliar field before entering it all-out. When planning to diversify, an outside laboratory can be used initially to minimize the cost and capital investment of exploring a new area.

7. Outside engineering organizations can approach a problem with objectivity. They have no preconceived design concept of the method of obtaining the product's function or how it should look. Independent research and development organizations inject new creative approaches to traditional design problems. Cross-fertilization of ideas results when they are drawn from many fields, perhaps entirely outside the scope of the client's activities.

8. Troubleshooting and checking staff conclusions are advantageously done outside. If laboratory results don't work in practice, an independent group may be able to find out why in a hurry.

9. Independent testing may formulate claims that can be used legitimately in advertising. Possible embarrassment or even prosecution is avoided by making only those claims that an independent laboratory will back up. Some firms will referee disputes and testify in litigation. If it is necessary to go to court, the expert testimony of an independent organization is often essential to a fair hearing of the case.

ect should be written up in detail so that proposals for the job may be obtained.

If there are differences of opinion within the client organization regarding the performance specifications, an outside firm may be able to assist in harmonizing these differences and develop a detailed statement covering what is required. Until the problem is clearly understood and an approach to its solution developed, it is impossible to set up a budget estimate.

Selecting the Outside Firm

Once the decision to go outside has been established, finding the right organization becomes the problem. When placing a development project outside, the engineering firm actually becomes a part of the technical staff while on the assignment. Geography may be one basis for selection. The close relationships required in professional development work make easy accessibility for plan-

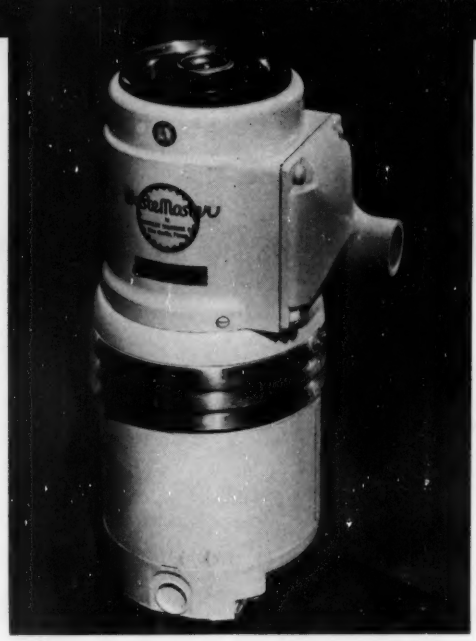
The Technical Survey

What It Is: An industrial technical-economic-market investigation is the organized process of obtaining data on user requirements, applications, competitive products, market conditions, and business potentials. It is a means of establishing objective specifications for product design.

Value in Planning: Entering upon a product-development program without careful consideration of valid facts on present and future market requirements and applicable technical and economic factors is both unrealistic and costly. Obtaining objective information and analyzing it to establish specifications results in efficient investment, assured market acceptance, and increased sales and profits.

How It Is Made: The problem is defined and an interview questionnaire prepared. The number and type of field contacts is decided. Field engineers gather the desired information and reactions from personal contacts. This is collated, examined, analyzed, tabulated, evaluated and summarized to determine trends, facts, areas of disagreement and conclusions. The survey presents facts for use in management judgement and makes specific recommendations for steps to be taken or improvements to be made.

Uses for Survey: The survey can check buyers' tastes and demands and show the firm's position with respect to competition. Untouched fields for research and development can be probed to eliminate the obsolescence factor in development work.



Case History—Garbage Disposer

Project

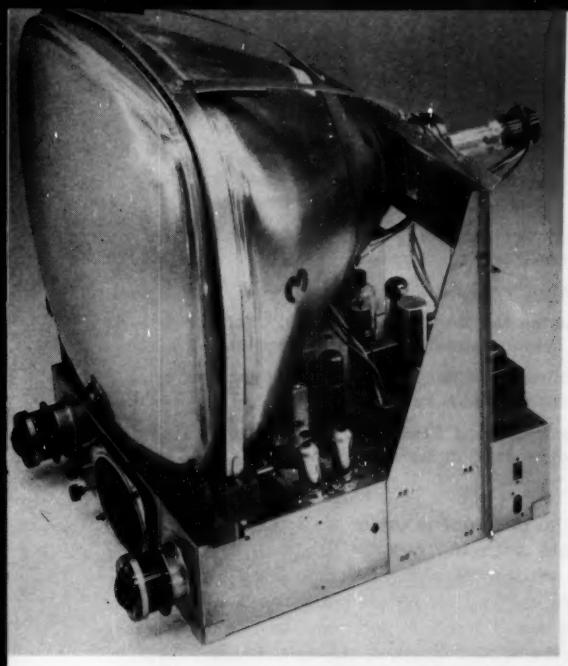
1. Lengthen working life of wearing parts.
2. Design entirely new mechanism unlike any automatic disposer yet produced.
3. Make parts replacement easier.
4. Reduce cost over manufacturer's present model, as well as competitive models.

Procedure

1. Client made detailed studies on desirable time-factor for disposal of all types of refuse (from lettuce to bones). Specifications based on this study.
2. Specifications set up with client for serviceability, ease of installation, and manufacturing cost.
3. DfI engineering study made to determine means of reducing number of parts to cut costs and simplify servicing and maintenance.
4. Client's basic idea for method of shredding waste studied and a practical design developed.
5. Several operating models built, tested and modified until new shredding method was developed to maximum efficiency.
6. Pre-production prototype built, and complete manufacturing drawings prepared.
7. Suppliers established for new tools required and tooling specifications prepared.

Results

1. Tests under true operating conditions showed that unit lasted up to three times longer than previous equipment before parts replacement was required.
2. Simplified design makes it possible for average homeowner to service the disposer, thus reducing upkeep costs.
3. Manufacturing costs reduced up to 50 per cent due to use of new-type, low-cost shredder, and standard instead of special motor.
4. Rough-in dimensions cut to two thirds those of competitive units, greatly simplifying installation.
5. Vibration reduced to minimum, eliminating noise and annoyance.
6. Design provided client with a number of patentable features, giving an edge on competition.



Case History—TV Receiver

Project

1. Develop entirely new line of 17 and 21-in. television receivers.
2. Cut costs below previous models without sacrificing performance.

Procedure

1. Comprehensive study made on current status of TV-receiver design and circuitry.
2. Client's and competitive receivers analyzed. Field checks made with consumers, distributors, dealers and service personnel to determine preferences or complaints.
3. Functional block diagram prepared to establish standards and limitations for each function. Most suitable circuit selected to perform desired functions based on economy, reliability and performance.
4. All circuits integrated to form efficient operating system.
5. Mechanical layout and circuit work, including use of printed circuits, carried to final form. Attention given to ease of manufacture and servicing as well as production economy.
6. Additional cost reductions achieved by simplification of circuitry, use of new sheet metal techniques and improvements in assembly operations.
7. Performance tests, including field testing both in fringe areas and strong signal areas, carried out. Necessary modifications incorporated in final design data.
8. Cabinet and chassis redesigned, as based on field survey results, to provide increased customer appeal.
9. Prototype models, final drawings, bills of material, and cost and process sheets, delivered to client.

Results

1. Thirty per cent reduction in manufacturing cost without sacrificing performance.
2. Simplified chassis design and wiring layout provided client with a receiver that was much easier to produce and service.

ning sessions and conferences a definite advantage. This would indicate choosing an organization close to you.

However, other considerations may easily override geography. If the right organization for the job is located in another city, they should be contacted regardless of distance.

Special qualifications or fields of experience required to handle the job will be an important factor in making a choice. Independent organizations sometimes specialize in certain types of products or materials, in industry classification, in area of primary interest and experience, and in their facilities and equipment. An organization may have individual experts in certain fields.

These distinctions are important when making a selection. The organization selected should be the one that meets the specific requirements. They must have the facilities, personnel, experience and interest required to undertake the problem. The prospective client must satisfy himself that the outside group will work for him rather than his people work for them.

People that are liked are those best to work with. This is intangible, but is essential for a successful co-operative venture. The firm selected should consist of individuals who are liked, respected and can be trusted. A good index is to qualify the engineering firm's personnel as the kind of men the client would like to have on his own payroll. If time is important, the outside firm's work load should be evaluated to make certain they have the time to do the job. Since technical service is their business, time is being purchased. Therefore, the schedule should be consistent with project requirements and should anticipate internal scheduling within the firm doing the job.

Before placing the project, the client should become familiar with the outside group first hand. It is best to visit their headquarters to meet and discuss the problem with their management and the personnel who will do the job. Also, it is possible to evaluate the physical facilities offered by the firm. This helps provide the solid basis of mutual understanding required for two organizations to work together.

The proposal should tell precisely what it is proposed to do, about how long it will take, about how much it will cost, and what it is thought can be accomplished. The budget estimate should be a conservative and detailed calculation of the number of hours required by each classification of personnel multiplied by the standard hourly rates.

Normally, when the proposal is signed, authorization is given to proceed, subject to the right to end the project at any time should it be desired and without further obligation except for payment of accumulated charges. During the course of the project, should developments at any time indicate that an increase in the budget will be necessary, advice should be given promptly, but the

budget should not be exceeded without first obtaining approval.

The client determines the scope of the work and the rate of effort. Charges should be invoiced in sufficient detail for the client to check progress against the budget and at all times be in complete control of the project.

Importance of Close Co-operation

After the job has been let, the outside firm begins work. Liaison people assigned by the client should be familiar enough with the specific problem, their organization and its capabilities, limitations, policies and procedures that they can answer questions raised during the course of the project.

Liaison people help the consultant firm find its way around and acquaint them with abilities and limitations of the client's firm, so that efforts may be channeled to the best interests. Both must develop the freedom of expression and mutual trust which expands the capacity for the combined effort of both groups working together. This cooperative effort results in far greater accomplishment. A basic concept of consulting is "working with people." A close relationship with the personnel concerned must be established and maintained.

Willingness to discuss the project, its problems and progress contributes materially to its success. The client's people up and down the line must be informed why consultants have been called in and what both hope to accomplish. The client must give the benefit of his experience in his own field so that it may be put with the consultant's broad background to advance the state of the art. The consultant should not have to dig for information that the client has acquired at considerable time and expense.

Development of the Project

Depending on the nature of the project and the particular services desired, a sample of the existing product, drawings, operation sheets, literature and manuals, present data, service reports and test data may be needed from the client. The operations to be performed, i.e., technical survey, patent survey or infringement search, research and development, manufacturing drawings, process costing, prototype, or pilot production will determine these requirements.

The work done by the consulting firm usually consists of eight separate steps.

1. **Analysis:** Determining the elements of the problem and the relationships existing between them.
2. **Planning the Treatment:** Determining some tentative order of investigation.
3. **Investigation:** Gathering and evaluating data and material and drawing conclusions.
4. **Designing:** Arranging the material so that it accomplishes its purpose.
5. **Constructing:** Applying the design.
6. **Checking the Results:** Determining if the product actually accomplishes its purpose.
7. **Modification:** Changing the product in light of evidence provided by the check.
8. **Preparing Final Product:** Turning out the finished product in its final form.

Once the program is under way, plan scheduled conferences with the outside group to jointly review the project. Talk over the project but do not encourage an opinion before it is ready. A joint review is also a good opportunity to see how the group is doing and to see if the choice was sound. Compare performance against the proposal. Is the group on schedule, and are they doing the job as proposed? Also check to see if they are conclusion jumpers, criticizing your people, policies, methods and procedures after only superficial observation. Are they unnecessarily throwing their weight around?. If these questions cannot be satisfactorily answered, cancel the project and write it off as a mistake. This is an area where engineering management must be exercised.

The outside group presents the results as a report. Determine what type of report is expected. Get together with the group to decide who is going to read the report so that subsequent action can be taken. Will it be the board of directors, engineering management, production people, or all three? What purpose will the report serve? Will it be a how-to-do-it, why-was-it-done, or a new product ready to put into production? Certainly the report should be prepared and presented so its recommendation can be put into effect. At DfI we prefer to present complete manufacturing specifications, cost and process sheets, detailed manufacturing drawings, and a functionally tested production-prototype model.

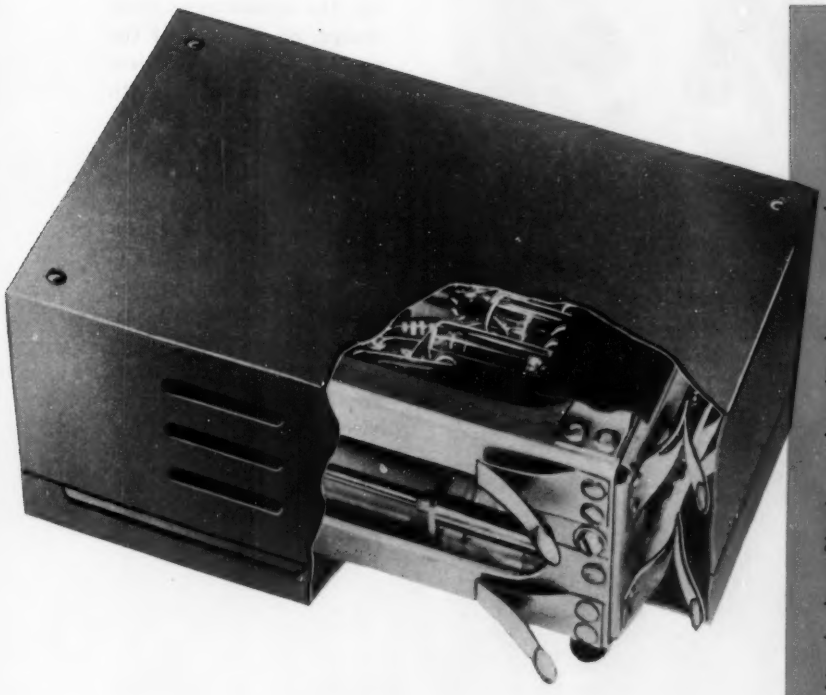
When the development project is complete, the real job is only begun. Remember that ideas lying around unused can quickly mold away into obsolescence before much time has elapsed. Put the results of the project into immediate effect and exploit the investment.

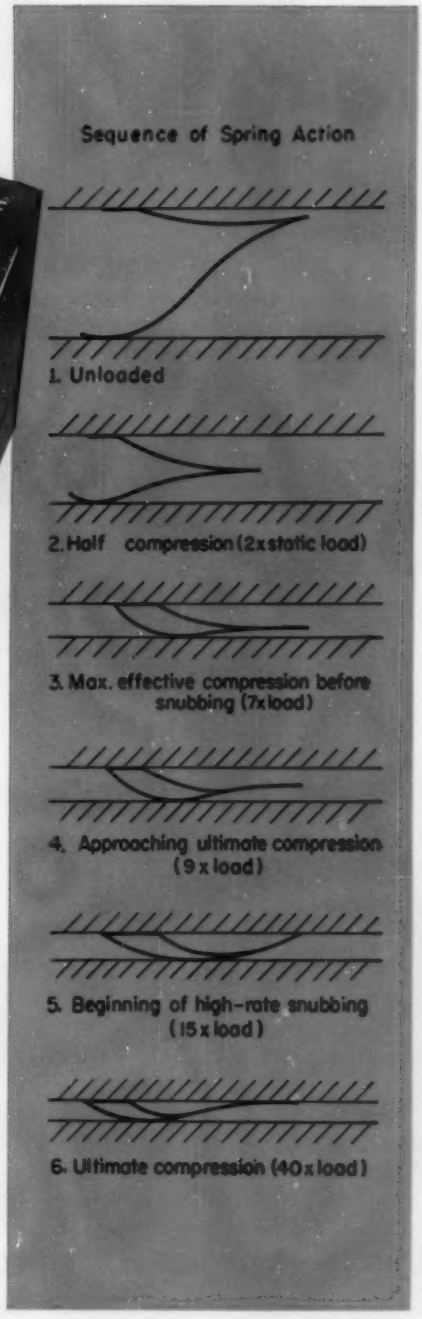
Hydraulic Servos

In Part 3 of "Hydraulic Servos," March 21 issue, two errors occurred. The first part of Equation 44, Page 163, should be: $a + T = 0.005$. Following Equation 48 on Page 164, the first defining equation should be: $K_3 = 2\pi n r V_p / 60 L_p V_m$.

"Modern science is the real source of economic progress."—ALFRED P. SLOAN.

scanning the field for *ideas*





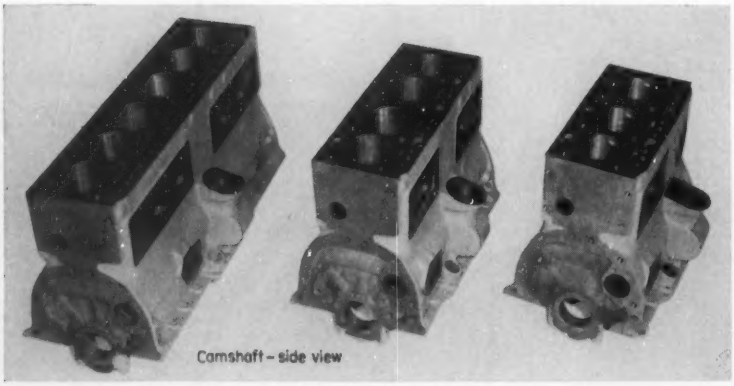
Folded steel leaf springs are used to shock mount sensitive instruments in three dimensions. Developed by the Leland Electric Co., division of American Machine and Foundry Co., the mounting system employs four folded, stainless-steel springs attached at their inner ends to each face of the inner box which contains the equipment to be isolated. The outer ends of these springs are free to bear against the interior of the outer case.

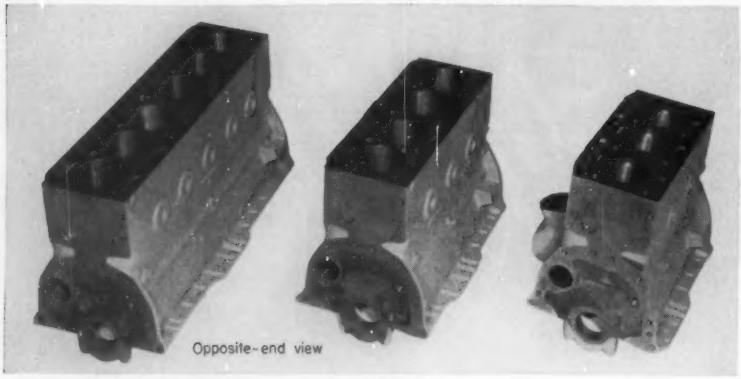
The folded springs are designed for high shock absorption by developing relatively high spring rates as they approach total compression. Damaging resonance vibrations arising in the isolating mount are minimized by designing the mounting system to resonate at a low frequency and to have low energy for normal vibration amplitudes. Additional damping designed into the springs selectively limits any resonant amplitudes at higher frequencies.

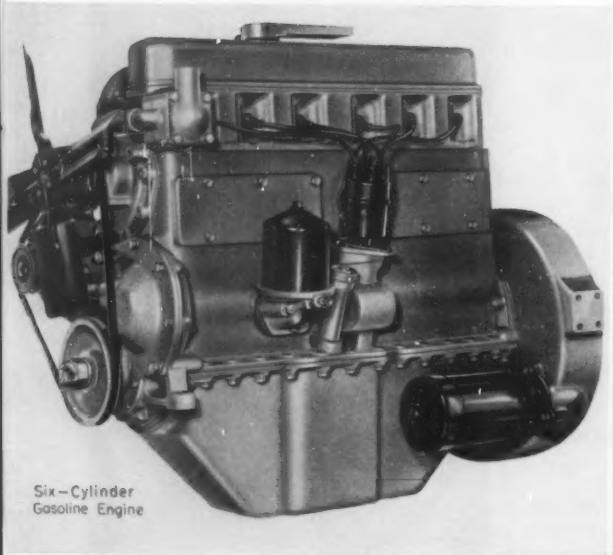
Symmetrical cylinder-block design for interchangeable application on diesel or gasoline engines offers flexibility in assembly and installation. Used in a line of three, four and six-cylinder engines developed by Hercules Motors Corp., the reversible-block construction permits placing of the accessory drive equipment and manifolds on the side of the engine best suited to specific application requirements.

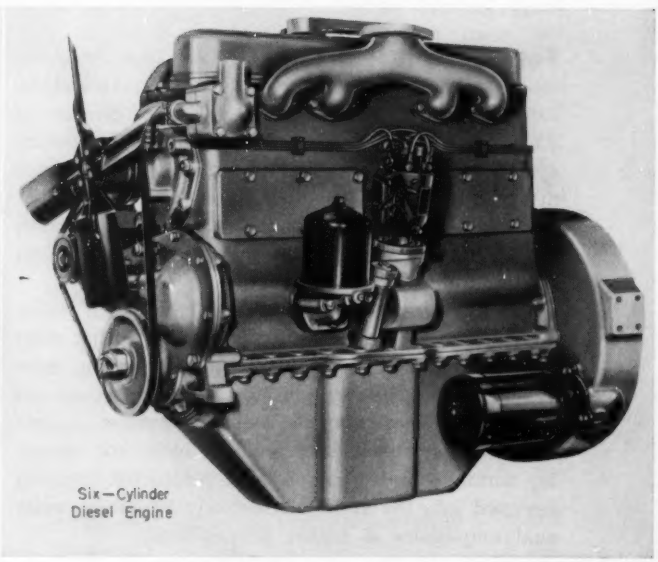
Both ends of the cylinder block are identical in design, and the blocks are symmetrical about the transverse centerline. Therefore, the bellhousing and timing-gear cover can be mounted on either end.

In an 18-model line using the symmetrical block design, 85 per cent of the parts are common. In gasoline or diesel models with the same number of cylinders, the cylinder blocks, crankshafts, valves and valve gear, connecting rods, gear covers and bellhousings are identical. The exchange of fuel-injection pumps, cylinder heads, pistons and manifolding is all that is required to convert from gasoline to diesel or vice versa.

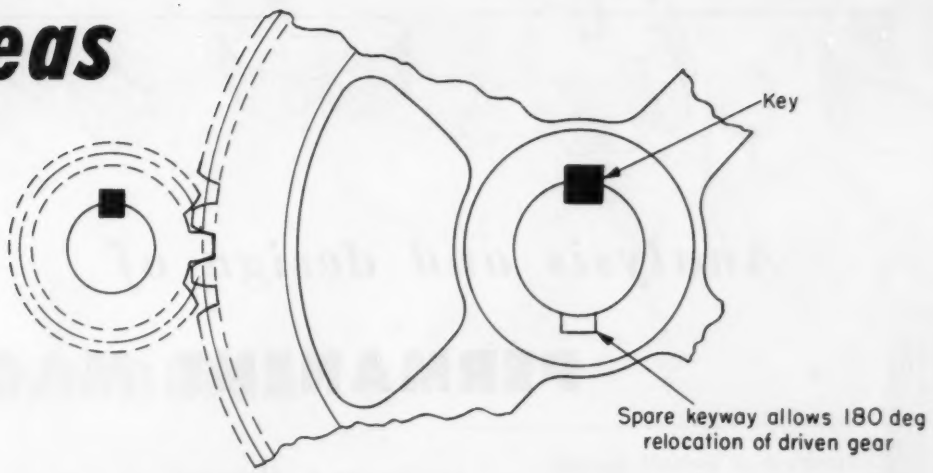

Camshaft-side view


Opposite-end view


Six-Cylinder Gasoline Engine

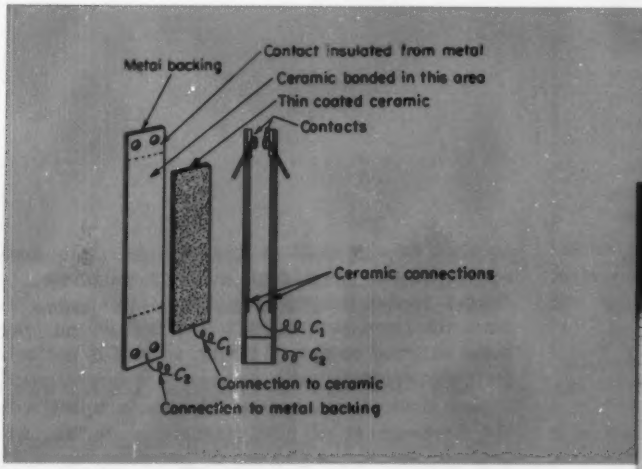

Six-Cylinder Diesel Engine

ideas

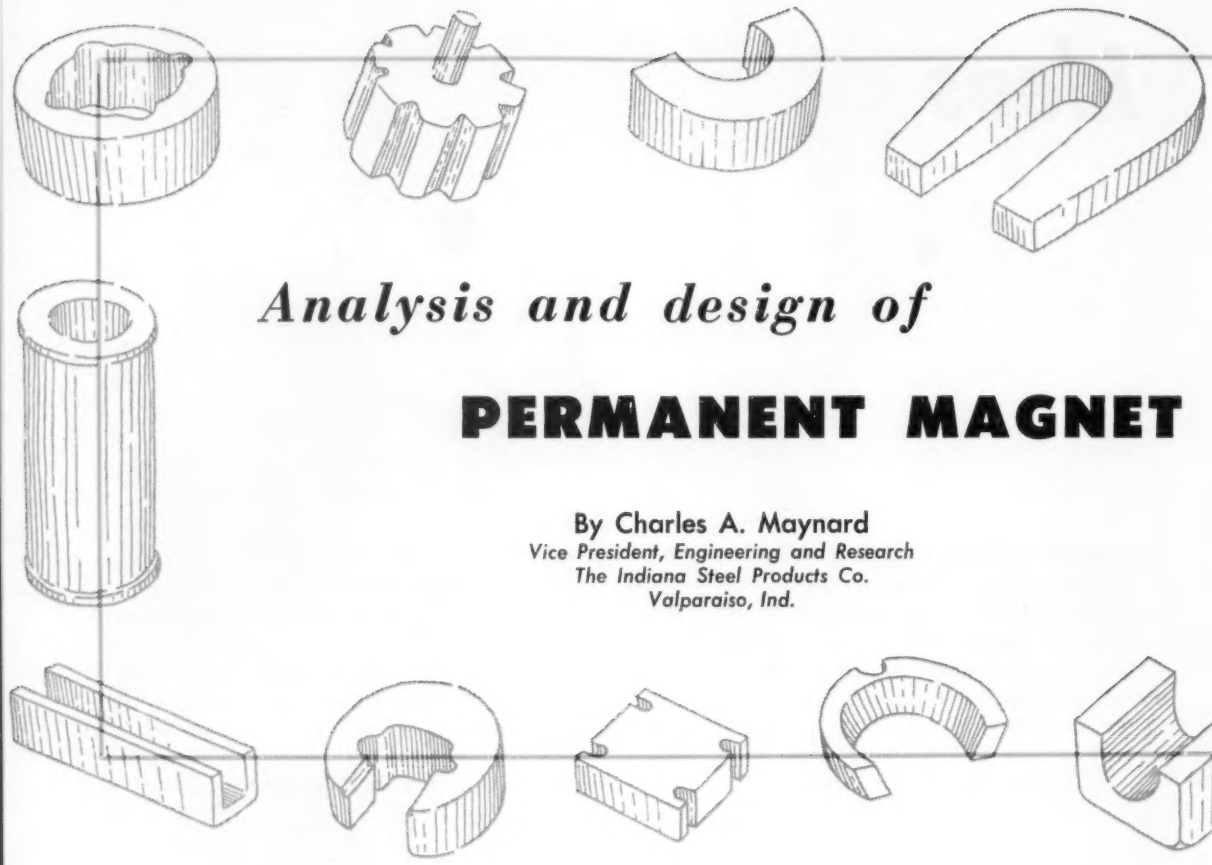


Angular position adjustment of gears for distribution of wear is simplified by a keyway-location technique described by Clint McLaughlin, Queens, N. Y. Intended for gears that carry high loads on only a portion of their circumference, the method consists of locating gear keyway about 90 deg away from heavily loaded teeth. When drive gear wears, it is pulled, turned over, and remounted, exposing teeth that were originally 180 deg away from heavy wear conditions. This approach is only suitable for full gears with symmetrical hub designs.

Another possibility is to design gears with two or more keyways so they can be repositioned on their shafts when certain teeth show wear. If hubs are symmetrical, they can also be pulled, reversed and remounted in another position.



Electrostrictive bending action controls switching in a nonmagnetic relay construction. The Capaswitch relay developed by the Mullenbach Div., Electric Machinery Mfg. Co., is designed with an electrostrictive ceramic element bonded to a metal backing to provide the required mechanical actuating force to close the contacts. When voltage pulses are applied to the ceramic, it shrinks lengthwise causing the "composite beam" to bend in the same direction regardless of charge polarity. Each relay uses two such beams placed face-to-face.



Analysis and design of

PERMANENT MAGNET

By Charles A. Maynard
Vice President, Engineering and Research
The Indiana Steel Products Co.
Valparaiso, Ind.

PERMANENT magnets function as transducers in changing energy from one system to another. As such, their applications can be divided into several classifications:

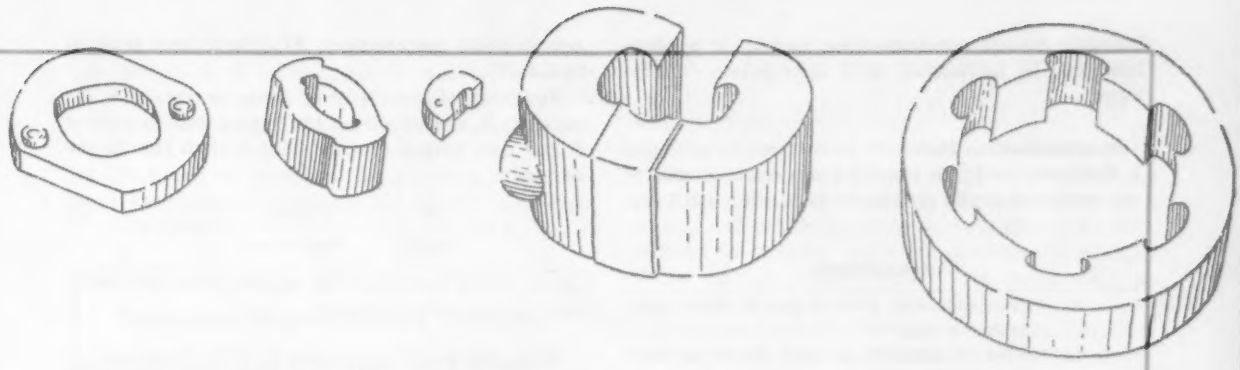
1. *Mechanical to mechanical* attraction and repulsion.
2. *Mechanical to heat,* such as in eddy current and hysteresis torque devices.
3. *Mechanical to electrical,* such as generation of a voltage in control and power devices.
4. *Electrical to mechanical,* such as in motors, loudspeakers, d'Arsonval meters, electron or ion beam deflection, mass spectrometers.
5. *Special effects,* such as magneto resistance, Hall effect, nuclear magnetic resonance.

Permanent magnets have many inherent advantages. They produce a constant field which may be used to advantage in instruments and control devices. Permanent magnets eliminate the need for a power source required to keep an electromagnet energized. This can be a major factor in simplification of a device, especially when the magnet is part of a moving element, or when the device is to be portable. The permanent magnet introduces no additional heat in the device, since it requires no supply of external energy. In hazardous locations, permanent magnets eliminate the danger associated with electrical circuits. Also, since the permanent magnet does not depend upon some external source of power, service is not subject to power variation.

New devices and new techniques, coupled with the development of new magnetic materials, will continue to expand the use of permanent magnets in many fields.

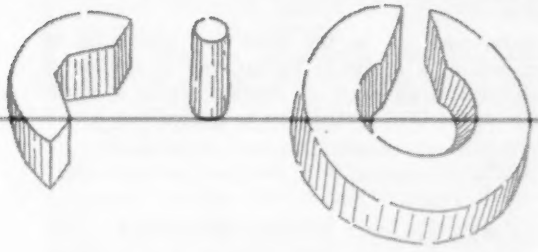
To design a permanent magnet, the designer must be familiar with the fundamental characteristics of ferromagnetic materials. The magnetic circuit and its properties must be understood, as must the design calculations employed. Basically, the solution to a design problem for a permanent magnet ultimately gives the "length" and "cross-sectional area" required to meet the given specifications.

The ideal solution results in a magnet size and shape that employs the minimum magnetic material. Practical considerations—such as cost of material, physical properties of the ferromagnetic material, size limitations, and others—can readily



ASSEMBLIES

A step-by-step guide showing how to design a magnet assembly to produce the required magnetizing force and flux density.



modify this ideal. More realistically, the design goal is to develop a magnet which will result in minimum cost consistent with the application.

Permanent Magnet Characteristics

Characteristics of permanent magnets are most easily shown by the graph in Fig. 1. This is a typical magnetization curve and hysteresis loop. Magnetizing force is shown on the horizontal co-ordinate, and the resultant magnetic flux density on the vertical co-ordinate.

To make these values applicable for design purposes, they are given standard units. Three electromagnetic systems of units are currently used in the field of magnetism: the CGS system based on the centimeter, gram and second; the nationalized MKS system based on the meter, kilogram and second; and the English system based on the inch, pound and second. Care must be exercised in conversion to be sure appropriate factors are used.

Unless otherwise specified, the CGS system will be used in this article. However, reference will

Design Method in Magnetics

Ideally, a final design for a magnetic assembly involves several discrete steps:

1. Specifying the design parameters external to the magnet assembly (force, required movement, torque, etc.).
2. Determining the required magnetomotive force F, and flux ϕ, to produce the results desired in step 1.
3. Designing the magnet assembly to produce the required ϕ and F. This involves two decisions:
   a. Choice of permanent-magnet material.
   b. Proper design of the magnet-assembly configuration.

This article, based upon a forthcoming *Permanent Magnets Design Manual,* is concerned only with step 3. It presumes that the required B in an air gap and H are known, and goes on from there to show how the magnet assembly can be designed.

For example, the attraction force between two parallel surfaces with lines of force passing between them at right angles to the surfaces[1] is

$$G = (5.77 \times 10^{-7}) B_g^2 A_g$$

where G is in pounds, B_g in gauss, and A_g in sq in. This equation, however, represents the situation when the armature is in contact with the magnet (zero gap).

If the armature is removed, as it must be in any practical application, a demagnetizing influence is brought to bear. The air gap moves from zero to some value. Other effects must then be taken into account.

Also, most magnet assemblies are not simple loops consisting of only a magnet and follower. Practical assembly, maximum efficiency and minimum cost will often suggest several magnet configurations, and usually the inclusion of soft iron pieces in the magnetic loop. All of these affect the flux density and magnetizing force in the air gap. How to adjust these factors to accomplish the desired B and H in a practical magnet assembly design is covered here.

Basic references which consider how to determine required magnetizing force and flux density for different devices are:

1. James R. Ireland—"Permanent Magnets," MACHINE DESIGN, April, 1949. (Attracting and holding devices, follower torque systems, hysteresis torque systems, eddy-current torque systems.)
2. H. C. Rotors—*Electromagnetic Devices,* John Wiley & Sons, Inc., New York, 1941.

be made to the other systems, and their application will be introduced with appropriate calculations.

Magnetomotive Force, F, is that which produces a magnetic field. In the CGS system, the unit of measurement is the gilbert, *F*, and in the MKS system it is the ampere-turn, *NI*. The gilbert is equal to $0.4\pi NI$.

The unit of magnetizing force or magnetic intensity, *H*, is defined as the magnetomotive force *F* per unit length. In the CGS system this is the oersted:

$$H = \frac{F}{\text{length}} = \frac{\text{gilberts}}{\text{centimeters}} = \text{oersteds}$$

In the other systems it is ampere-turns per meter and ampere-turns per inch.

Magnetic Flux, ϕ, induced in a magnetic circuit by a magnetomotive force is measured in maxwells or lines of force in the CGS system. In the MKS system the weber is used, which is 10^8 maxwells or lines.

Magnetic Induction, *B*, or magnetic flux density, is magnetic flux per unit area. In the CGS system the unit of magnetic induction is the gauss, which is maxwells per square centimeter, and in the MKS system, the unit is the weber per square meter.

Reluctance, *R*, is the term for opposition to flux within a magnetic circuit and is similar to resistance in an electrical circuit. Value of reluctance in the CGS system can be determined by:

$$R = \frac{L}{\mu A} \qquad (1)$$

As with electrical circuits, conductance $(1/R)$ is often a more convenient term, so with magnetic circuits permeance, the reciprocal of reluctance, is frequently used.

Thus permeance, *P*, becomes

$$P = \frac{\mu A}{L} \qquad (2)$$

Permeability, μ, is equal to B/H. In the CGS system μ_v is unity for a vacuum.

Nomenclature

- A_g = Cross-sectional area of gap at right angle to line of flux
- A_m = Area of magnet at right angle to direction of magnetization
- B = Flux density; lines of force per unit area
- B_d = Flux density in magnet at operating point*
- B_g = Flux density in air gap
- B_r = Residual induction
- D = Diameter of bar magnet (without pole pieces)
- F = Force that produces flux; magnetomotive force or mmf
- F_d = External demagnetizing force acting on magnet
- H = Magnetomotive force per unit length; magnetizing force
- H_c = Coercive force
- H_d = Magnetomotive force per unit length of magnet*
- H_g = Magnetizing force in air gap
- L = Length
- L_g = Length of air gap parallel to flux
- L_m = Length of magnet parallel to magnetization
- NI = Unit of magnetomotive force; product of turns on a coil and current in amperes
- P = Permeance
- p = Permeance coefficient
- P_g = Permeance of air gap, $\mu A_g/L_g$
- R = Reluctance, $L_g/\mu A_g$
- r_f = Reluctance factor; ratio of total mmf produced by magnet to mmf in air gap
- V_m = Volume of magnet
- σ = Leakage factor; ratio of flux produced by magnet to flux in air gap
- ϕ = Flux; line of magnetic force
- μ = Permeability
- μ_Δ = Incremental permeability

*In any one calculation, B_d and H_d are simultaneously co-ordinates of the magnetic value of the magnet.

Dimensions

	Unit	CGS	MKS	English
ϕ	Flux	maxwell line of force	weber 10^8 lines	maxwell line of force
B	Flux density	gauss lines/cm²	weber/m²	lines/in.²
F	Magnetomotive force	gilberts	ampere-turns	ampere-turns
H	Magnetizing force	oersteds gilberts/cm	NI/m	NI/in.
A	Area	sq cm	sq m	sq. in.
L	Length	centimeter	meter	inch
V	Volume	cu cm	cu m	cu in.
μ_v	Permeability, vacuum	1	$0.4\pi \times 10^{-6}$	3.192

Conversion Factors

Multiply	by	to obtain
Inches	2.54	centimeters
Lines/sq. in.	0.155	lines per sq cm
Lines per sq in.	1550×10^{-8}	webers/sq m
Gauss	6.45	lines/sq in.
Gauss	10^{-4}	webers/sq m
Gilberts	0.79577	ampere-turns
Oersteds	0.79577	ampere-turns/cm
Oersteds	2.0213	ampere-turns/in.
Ampere-turns	0.4 π (1.257)	gilberts
Ampere-turns/in.	0.495	oersteds
Ampere-turns/in.	0.3937	ampere-turns/cm

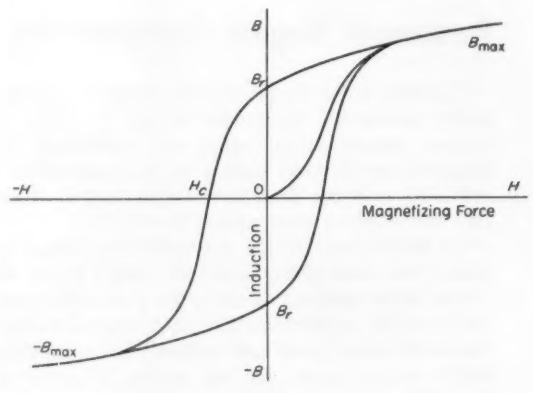


Fig. 1 — Magnetization curve and hysteresis loop, showing characteristics of permanent-magnet materials.

Flux and Mmf in a Magnet: Fig. 1 shows how the induction B in a magnetic material changes as the magnetizing force H is varied. From a graph of this type the qualities of a magnetic material are determined. Knowledge of the factors of the graph is necessary for selection of permanent magnet materials and for design of permanent magnets.

When demagnetized material is subjected to a gradually increasing magnetizing force up to H_{max}, the induction in the material increases from zero to B_{max}. If the magnetizing force is then gradually reduced to zero, the induction decreases from B_{max} to B_r on the vertical axis. This value (B_r) is known as the "residual induction."

If the magnetizing force is reversed in direction and increased in value, the induction in the material is further reduced, and it becomes zero when the demagnetizing force reaches a value of H_c, known as the "coercive force." A further increase of this negative force causes the induction to reverse direction, becoming $-B_{max}$ at $-H_{max}$. If the magnetizing force is reversed and increased from this point to H_{max}, the change in induction is along the curve $-B_{max}$, $-B_r$ to B_{max}. This completes

Permanent Magnets: Energy Producers

A permanent magnet is a body which, after having been subjected to a magnetizing force, produces a magnetic field external to itself without further energy being applied.

Permanent magnets are made from ferromagnetic materials which are usually alloys containing iron. A wide range of magnetic characteristics and physical properties is possible by varying the composition of magnetic materials. The ability of magnets made from various alloys to produce a field external to themselves is a result of material composition, thermal treatment, method of production and dimensions of the magnet.

In contrast to permanent-magnet materials, materials used for electromagnets cannot produce any appreciable magnetism when the magnetizing force is removed.

"Permanent"—What It Means: Theoretically, the external magnetic field produced by a permanent magnet will remain constant indefinitely, providing conditions in the magnetic circuit are also constant. Strength of the field may be affected temporarily or permanently by various factors. Chief among these factors are temperature changes, external magnetic fields, and contact with other ferromagnetic bodies. The magnet can be stabilized by appropriate procedures to minimize the effects of such external factors.

If properly designed and stabilized for a particular application, permanent magnets will produce an external field for many years with only a fraction of one per cent loss in magnetic strength.

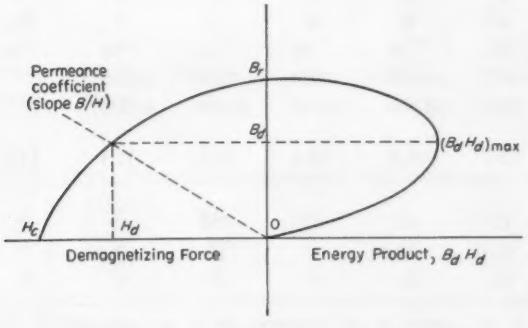


Fig. 2—Demagnetization and energy product curves.

Basic Electrical-Magnetic Analogies

Units of measurement used for permanent-magnet circuits are analogous to those for electrical circuits. Like electrical circuits, magnetic circuits are "closed loops" in which the permanent magnet plays the role of a power source (a battery, for instance). Some of the laws governing electrical circuits can be directly transferred to magnetic circuits.

Fundamental measurements in magnetics are defined in the text. However, analogies between these units and corresponding electrical units are:

Electrical	Magnetic
E (emf)	F (magnetomotive force, mmf)
I (current)	ϕ (magnetic flux)
R (resistance)	R (reluctance)

Conductance in an electrical circuit (the reciprocal of resistance, $1/R$) has its analogy in permeance P of a magnetic circuit (the reciprocal of reluctance, $1/R$).

Ohm's law in electrical work has its analogy in Ohm's law of the magnetic circuit:

Electrical	Magnetic
$E = IR$	$F = \phi R$

Kirchhoff's laws can also be extended to magnetic circuits. These laws, in magnetic terms, state:

1. Sum of fluxes entering a junction equals the sum of fluxes leaving that junction.
2. Algebraic sum of magnetomotive forces around a closed magnetic circuit equals the algebraic sum of the reluctance drops.
3. Difference in magnetomotive force (magnetic potential) between any two points in a closed magnetic circuit is the same along any path.

the hysteresis loop.

This type of curve applies to all magnetic materials, with different values applying to different materials. Materials having a low coercive force are low-energy materials, and those having a high coercive force are high-energy materials. These have been commonly known as soft and hard materials, respectively, but the terms low-energy and high-energy are more representative of the characteristics of the magnetic materials.

The section of the hysteresis loop from B_r to H_c is of major interest to designers of permanent magnets. This is known as the "demagnetization curve," and is shown at the left in Fig. 2. At the right of this curve is the conventional energy product curve, which is the product of B and H as taken from the demagnetization curve and plotted against B.

The product of B_d and H_d at any point on the demagnetization curve indicates the external en-

Table 1—Permanent

	Cast						
	Alnico I	Alnico II	Alnico III	Alnico IV	Alnico V	Alnico VI	Alnico XII
Magnetic Characteristics							
Peak energy product, $(B_dH_d)_{max} \times 10^6$	1.4	1.6	1.35	1.3	5.25	3.8	1.6
Residual Induction, B_r (kilogauss)	7.0	7.2	6.9	5.5	12.5	10.1	5.5
Coercive force H_c (oersted)	440	560	470	700	600	750	950
Permeance coefficient, B/H at $(B_dH_d)_{max}$	14.4	13.4	13.7	6.83	20	12.5	5.63
Induction, B_d at $(B_dH_d)_{max}$ (kilogauss)	4.5	4.7	4.3	3.0	10.2	7.0	3.0
Mmf per unit length, H_d at $(B_dH_d)_{max}$ (oersteds)	310	350	315	430	512	543	534
Incremental permeability (Note 1)	6.8	6.4	6.5	4.1	4.3	5.3	....
Peak magnetizing force required H_p (oersteds)	2000	2000	2000	3000	3000	3000	3000
Application and Design Factors							
Ability to withstand demagnetizing fields (Note 2)	G	G	G	E	G	E	Ex
Approx. temp. permanently affecting material (deg F) (Note 3)	1000	1000	900	1100	1000	1000	900
Preferred magnetic orientation (Note 4)	No	No	No	No	YH	YH	N
Importance of working at $(B_dH_d)_{max}$ (Note 5)	B	B	B	C	A	B	D
Material Characteristics							
Weight (lb per cu in.)	0.249	0.256	0.249	0.253	0.265	0.268	0.264
Mechanical properties (Note 6)	HB	HB	HB	HB	HB	HB	HB
Critical materials present	Co, Ni	Co, Ni	Ni	Co, Ni	Co, Ni	Co, Ni	Co, Ni
Relative material cost per unit of energy (Note 5)	B	B	A	B	A	B	C
Relative processing cost (Note 5)	B	B	B	B	C	C	E
Electrical resistivity at 25 C (microhm-cm)	75	65	60	75	47	50	62
Tensile Strength (psi)	4100	3000	12,000	9100	5450	23,000	....
Transverse modulus of rupture (psi)	13,900	7700	22,500	24,000	10,500	45,000	....
Coefficient of thermal expansion (per deg C $\times 10^{-6}$)	12.6	12.4	13.0	13.1	11.3	11.4	11.0
Manufacturing Methods and Limitations							
Method (Note 7)	C	C	C	C	CM	C	C
Shape limitations (Note 8)	C	C	C	C	C	C	C
Machinability (Note 9)	G	G	G	G	G	G	G

1. Approximate value.
2. P, poor; F, fair; G, good; E, excellent; Ex, exceptional; S, superior.
3. See section on *Thermal Properties*.
4. YH, oriented in heat treatment; YR, in cold reduction; YP, in pressed direction (slightly).
5. A, most important; D, least important. For cost comparisons, A indicates lowest cost, D indicates highest.
6. H, hard; B, brittle; M, machinable; D, ductile; A, annealed for

ergy produced per unit of volume for different points on the curve. In the CGS system where B_d is in gauss and H_d is in oersteds, $B_dH_d/8\pi$ is equal to ergs.

The external energy is zero at both B_r and H_c, and reaches a peak value at a point known as the "peak energy product," $(B_dH_d)_{max}$. This point represents the maximum external energy that can be produced by a unit volume of a given material. It is the criterion for comparing the values of different permanent magnet materials. Furthermore, it will be seen that, in the case of fixed air-gap application, the design which causes the magnet to work at the maximum energy point will require the least volume of magnet material.

A graph developed by Indiana Steel Products Co. eliminates the need for calculating the energy product curve. This is shown in Fig. 3. The prod-

Magnet Materials

Sintered							Ductile		Formed		
Alnico II	Alnico IV	Alnico V	Alnico VI	Indalloy	Indox I	Indox V	Cunife 1	Cunico	Chrome 3½%	Cobalt 17%	Cobalt 36%
1.45	1.2	3.5	2.75	0.9	0.9	3.25	1.3	0.8	0.29	0.65	1.0
6.9	5.2	10.5	8.8	9.0	2.2	3.7	5.4	3.4	9.5	9.5	10.0
520	700	600	800	240	1600	1950	500	700	60	150	240
12.7	7.5	17.4	11.0	40	1.25	1.6	12.3	5	142	55.5	39.6
4.3	3.0	7.8	5.5	6.0	1.05	2.5	4.0	2.0	6.4	6.0	6.3
340	400	450	500	150	850	1625	325	400	45.3	103	159
6.4	4.1	4.0	....	10.5	1.1	1.05	1.7	3.2	37.0	13.0	10.2
2000	3000	3000	3000	1000	12,000	10,000	2400	3200	300	1000	1000
G	E	G	E	F	S	S	G	E	P	F	F
900	1100	1000	1000	....	1800	1800	900	....	250	300	300
No	No	YH	YH	No	YP	YH	YR	No	No	No	No
B	C	A	B	B	D	C	B	D	B	B	B
0.243	0.250	0.241	0.241	0.288	0.167	0.18	0.311	0.300	0.281	0.302	0.296
H	H	H	HB	H	HB	HB	D	D	H	H	H
Co, Ni	Co, Ni	Co, Ni	Co, Ni	Mo, Co	....	....	Ni	Co, Ni	....	Co	Co
C	C	B	B	D	A	A	C	E	C	D	D
B	B	C	C	B	B	E	D	D	A	B	B
68	68	50	....	48	10^{12}	10^{10}	18	24	29	23	25
65,000	60,000	50,000	....	125,000	Low	Low	100,000	85,000	300,000	300,000	300,000
70,000	85,000	....	....	....	10	....	....	....	....	....	....
12.4	13.1	11.3	....	9.3	....	10.0	14.0	14.0	13.6	15.9	17.2
S	S	SM	SM	S	S	S	CR	CR	HR	HR	HR, C
P	P	P	P	P	P	P	Fa	b	F	F	F
G	G	G	G	A	G	G	Yes	Yes	A	A	A

machining.

7. C, cast, heat treated; CR, cold reduced; HR, hot rolled and formed; M, cooled in magnetic field; S, pressed from powder and sintered.
8. C, cast; P, pressed; F, formed from rolled stock; a, maximum cross-section is 0.1 sq in.; b, check with supplier.
9. G, grind only; holes cored at time of casting; A, annealed for machining.

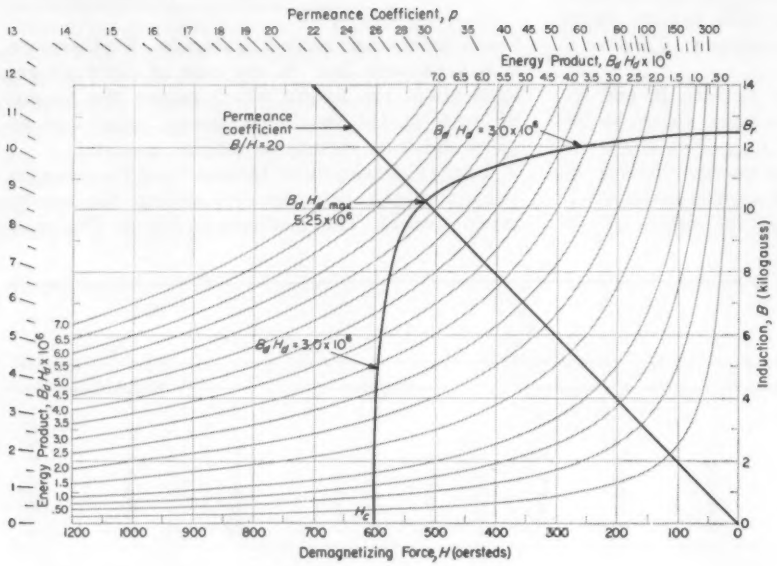


Fig. 3—Demagnetization curve plotted to permit direct determination of energy product.

uct of B_dH_d is obtained directly from the inner section of the demagnetization curve and the hyperbolic curves indicating the energy product.

Energy product values between the intersection of the various hyperbolic curves and the demagnetization curve are determined by interpolation. This system of curves also gives values for the minor hysteresis loops, which will be considered later.

Magnetic characteristics of various commercial permanent magnet materials are shown in Figs. 4 through 8. These curves, together with the additional information in Table 1 and the following discussion on magnet design, will give the designer a practical approach to the use of magnets.

The Magnetic Circuit

Magnetic circuits using permanent magnets are divided into two basic classifications: Circuits with fixed air gaps, and circuits with variable air gaps, Fig. 9.

In general, such circuits have three elements: The permanent magnet, the useful air gap, and the iron paths for the flux. In any magnetic circuit utilizing permanent magnets, the energy produced by the magnet is equal to the energy in the balance of the circuit at all times. Magnetomotive force produced by the magnet determines the total flux in the external circuit since

$$\phi = \frac{F}{R} = FP \qquad (3)$$

Thus, there is an Ohms law for magnetomotive force, flux, reluctance and permeance in the magnetic circuit which parallels the Ohms law for emf, current, resistance and conductance in an electrical circuit.

Fixed Air Gap Designs

The basic factor in the design of a permanent magnet is that the magnet shall be capable of producing sufficient magnetomotive force to overcome the reluctance of the magnetic circuit and produce the desired flux in some element or elements thereof.

Without taking into account stabilization or transient demagnetizing conditions (which will be considered later), the design of a magnet is largely concerned with determining the basic dimensions and material to produce a given flux density in a fixed air gap with the minimum amount of material.

Length L_m and area A_m of a magnet necessary to produce a given flux density B_g or field strength H_g in an air gap are indicated by

$$L_m = \frac{H_g L_g r_f}{H_d} = \frac{B_g L_g r_f}{\mu_r H_d} \qquad (4)$$

$$A_m = \frac{B_g A_g \sigma}{B_d} \qquad (5)$$

where H_d and B_d are simultaneous values from the curve of permanent-magnet materials. Development and use of these two basic equations will be discussed in the following sections.

Magnet Length: In a fixed air gap having a relatively short length as compared to its smallest cross-sectional dimension, the magnetomotive force required to produce a given flux in the air gap is indicated by Equation 3:

$$F = \frac{\phi_g}{P_g}$$

From fundamental definitions,

$$\phi_g = B_g A_g$$

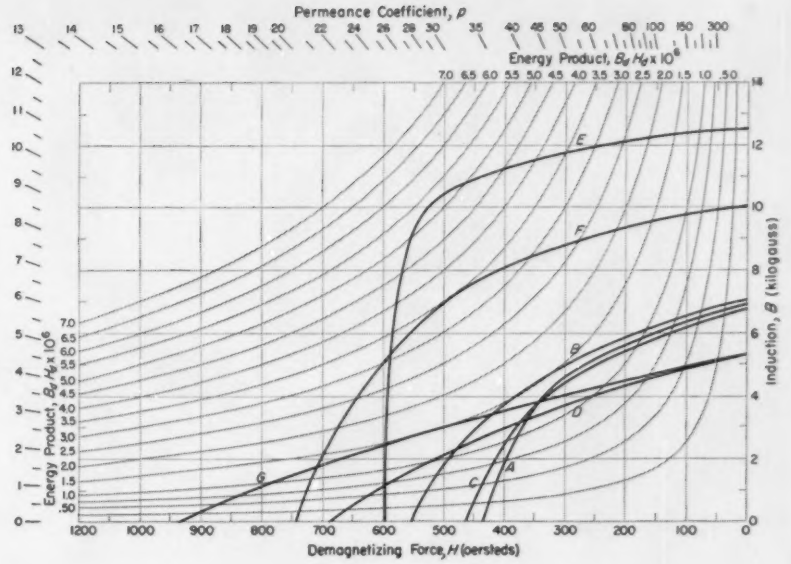


Fig. 4—Cast Alnico magnet characteristics: *A*, Alnico I; *B*, Alnico II; *C*, Alnico III; *D*, Alnico IV; *E*, Alnico V; *F*, Alnico VI; *G*, Alnico XII.

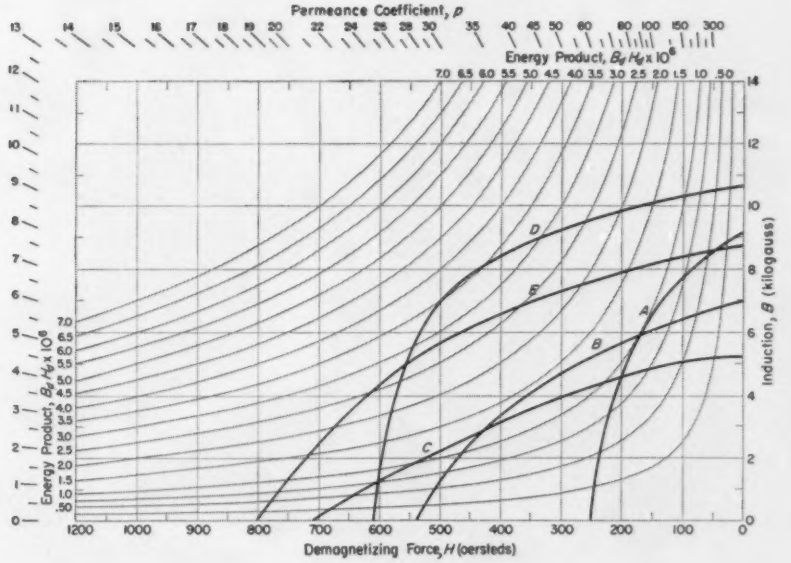


Fig. 5—Sintered magnet characteristics: *A*, Indalloy; *B*, Alnico II; *C*, Alnico IV; *D*, Alnico V; *E*, Alnico VI.

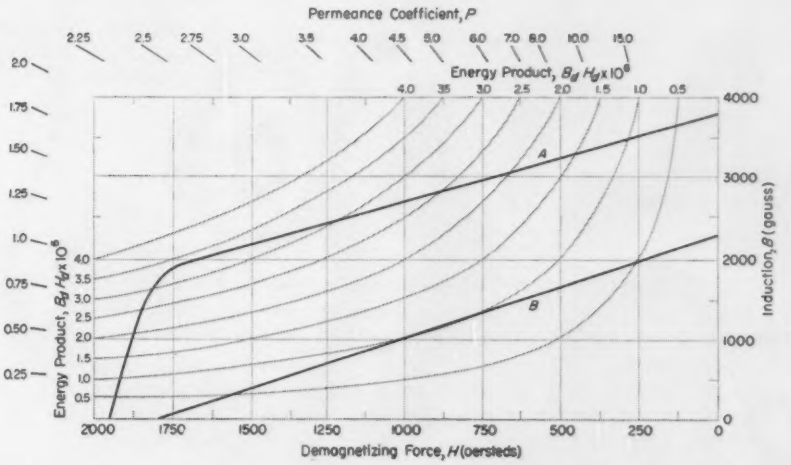


Fig. 6—Indox magnet characteristics: *A*, Indox V; *B*, nonoriented Indox I.

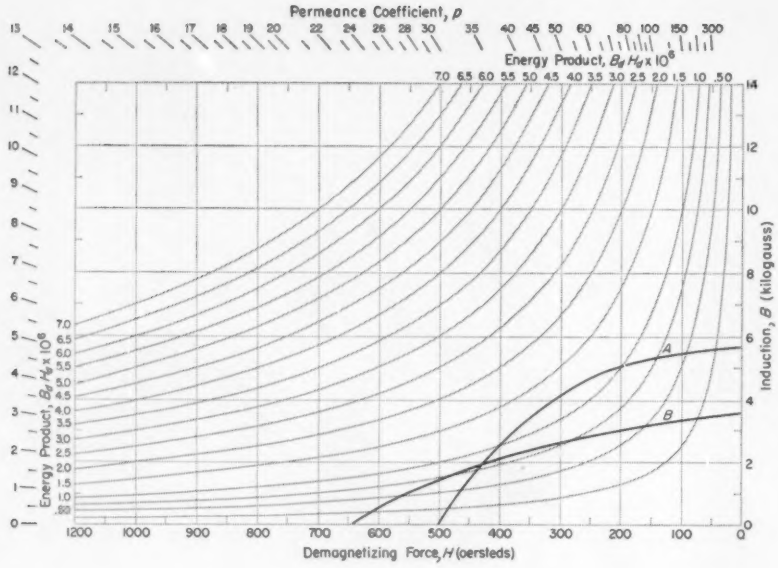


Fig. 7—Ductile magnet characteristics: *A*, Cunife I; *B*, Cunico.

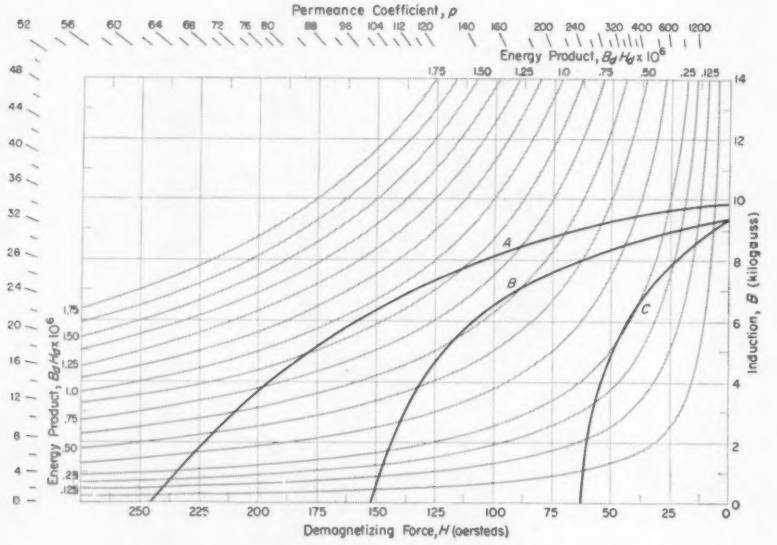


Fig. 8—Formed magnet characteristics: *A*, 36 per cent cobalt; *B*, 17 per cent cobalt; *C*, 3½ per cent chromium.

and from Equation 2,

$$P_g = \frac{\mu_v A_g}{L_g}$$

Therefore,

$$F = \frac{B_g L_g}{\mu_v} \qquad (6)$$

Inserting the value of $\mu_v = B_g/H_g$ in the previous equation gives

$$F = H_g L_g \qquad (7)$$

In the CGS system, since μ_v for vacuum is practically the same as that for air, μ_v can be considered as unity. Therefore, numerically, B_g and H_g are the same.

Magnetomotive force produced by a magnet is the product of its magnetizing force H_d at the operating point and its magnetic length:

$$F = H_d L_m \qquad (8)$$

Consequently, to produce a field intensity H_g in the air gap, the magnetomotive force produced by the magnet must equal that required for the air gap. Combining Equations 7 and 8,

$$L_m H_d = H_g L_g$$

and

$$L_m = \frac{H_g L_g}{H_d} \qquad (9)$$

It should be noted that the L_m in Equation 9 is necessary for the air gap only. Actual length required (Equation 4) may be greater as will be discussed under *Reluctance Factor*.

EXAMPLE 1: If a flux density H_g of 2000 gauss is required in a ¼-in. air gap, determine the correct length of magnet to utilize the magnetic material most efficiently.

Using Hyflux Alnico V for the magnetic material, and operating the magnet at the maximum energy product, B_d is 10,200 gauss, and H_d is 515 oersteds.

Inserting the modification, $H_g = B_g/\mu_v$, into Equation 9, the solution in CGS units becomes:

$$L_m = \frac{B_g L_g}{\mu_v H_d} = \frac{2000(0.25 \times 2.54)}{515}$$

$$= 2.455 \text{ cm} = 0.970\text{-in.}$$

In this case, $\mu_v = 1$.

A demagnetization curve plotted in the MKS system would show that at peak energy product B_d for Hyflux Alnico V is 1.02 webers per sq meter, and H_d is 4.1×10^4 ampere-turns per meter. For the problem given, B_g in the MKS system is 0.2-weber per sq. meter. Also, $\mu_v = 0.4\pi \times 10^{-6}$. Thus, the solution in the MKS system would be

$$L_m = \frac{0.2(0.25 \times 0.0254)}{(0.4\,\pi \times 10^{-6})(4.1 \times 10^4)}$$

$$= 0.02466\text{-meter} = 0.970\text{-in.}$$

Reluctance Factor: Since the magnetic circuit often includes soft-iron material and joints, the magnet must supply additional magnetomotive force over and above that needed for the air gap itself. The total magnetomotive force required for the circuit as compared to the magnetomotive force required for the air gap (based on physical dimensions) is known as the "reluctance factor" r_f.

Basically, the total magnetomotive force is determined by adding together the magnetomotive force required for the air gap, the magnetomotive force required for soft iron, the magnetomotive force necessary to overcome joint reluctance and the additional magnetomotive force necessary to accomodate the geometry of the air gap itself:

$$r_f = \frac{F_g + F_1 + F_2 + \ldots + F_n}{F_g}$$

$$= 1 + \frac{F_1 + F_2 + \ldots + F_n}{F_g}$$

The F required for joints is basically determined by the same equation as that given for a fixed air gap, Equation 6. Likewise, the F required for the iron circuit is determined by the same formula, except that the value of μ is determined by the induction in the iron circuit.

Geometry of the air gap may be such that additional magnetomotive force will be required over and above that for the simplified Equation 6 for the fixed air gap. If the gap is long as compared

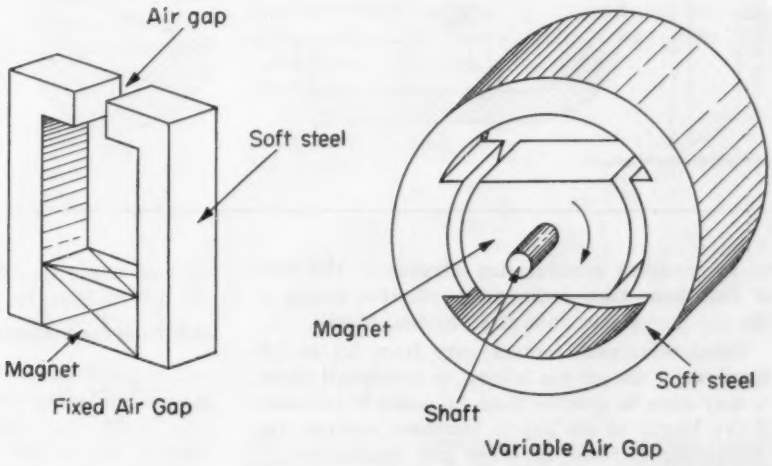
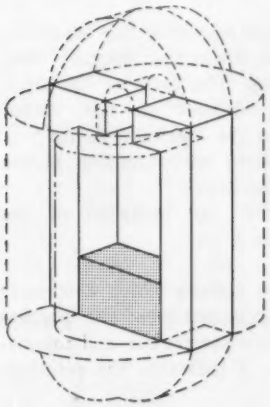


Fig. 9—Right—Two basic magnetic circuits: fixed air gap, and variable air gap.

Fig. 10—Below—Geometric configurations which simulate actual flux leakage paths.



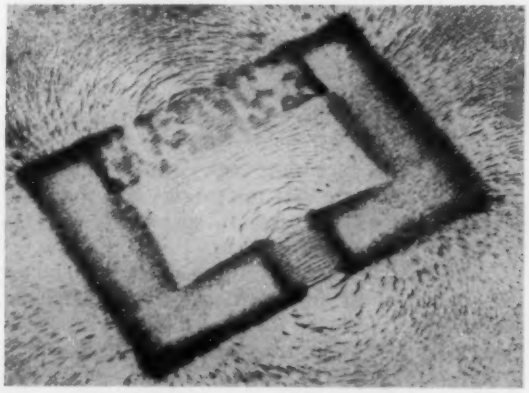


Fig. 11—Flux leakage paths shown by pattern of iron filings. Magnets are at sides of the assembly.

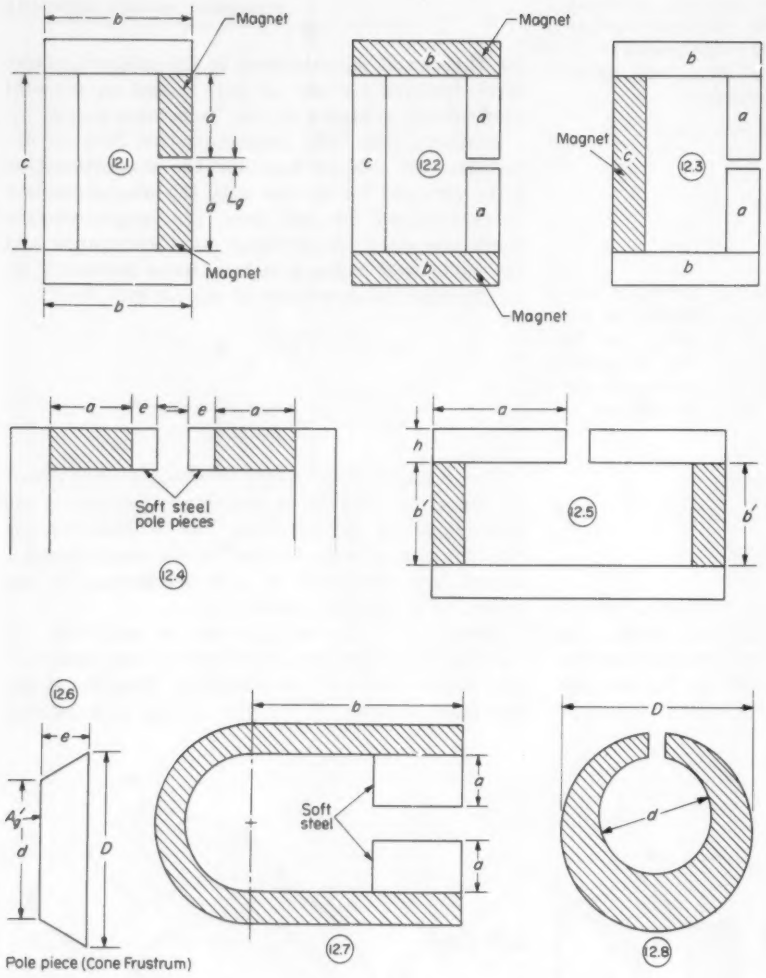


Fig. 12—Basic circuit configurations for determining leakage coefficients.

to its smallest cross-section dimension, the lines of flux bow, thus making the effective length of the air gap longer than the physical length.

Usual reluctance factors vary from 1.1 to 1.5. However, if the air gap is long, as mentioned above, r_f may even be greater than 2.5, since it increases if the length of air gap is increased without corresponding increase in other gap dimensions.

Having once determined the approximate value of the reluctance factor, it can be used in similar circuits without resorting to individual calculations for all the factors mentioned above. The reluctance factor is incorporated in Equation 9 to give Equation 4.

Magnet Area: Another important consideration in magnet design is that the magnet will have sufficient cross-sectional area to supply the flux required in the magnetic circuit.

Total flux produced by the magnet is equal to the product of its cross-sectional area A_m and the operating flux density B_d. If all the flux produced by the magnet were also present in the air gap, the formula would be

$$A_m B_d = \phi_g$$

and, from fundamental definitions,

$$A_m = \frac{B_g A_g}{B_d} \qquad (10)$$

Unfortunately, the solution is never this simple in practice, as all the flux from the magnet does not appear in the air gap. The ratio of the total magnetic flux in the magnet to the useful air-gap flux is known as the "leakage factor," σ. This factor and its method of evaluation is the subject of the following section.

Equation 10 is modified by inclusion of the leakage factor to Equation 5.

Flux Leakage: The two factors which determine the amount of flux which comes from any portion of the magnetic circuit are permeance and magnetomotive force. Equation 3 indicates the relationship:

$$\phi = FP$$

The leakage factor may be expressed as

$$\sigma = \frac{\phi_t}{\phi_g}$$

or

$$\sigma = \frac{F_t P_t}{F_g P_g}$$

where the subscript t is for total circuit values and g for air-gap values. If the total magnetomotive force is assumed equivalent to that across the air gap, then

$$\sigma = \frac{P_t}{P_g} \qquad (11)$$

Permeance can be determined from Equation 2,

$$P = \frac{\mu A}{L}$$

where A = area of two equal and opposite parallel planes, L = distance between the planes, and μ = permeability. For a vacuum, in the CGS system, $\mu = 1$, and it is essentially the same for air.

Total permeance can be obtained by breaking up the field into probable flux paths which have simple geometric configurations that simulate the actual flux paths, and which can be calculated. Thus, from the Equation 11, the leakage factor becomes the ratio of the sum of all the permeance paths to that of the air gap:

$$\sigma = \frac{P_g + P_1 + P_2 + \ldots + P_n}{P_g}$$

$$= 1 + \frac{P_1 + P_2 + \ldots + P_n}{P_g} \qquad (12)$$

Various geometric configurations which may be used for such calculations are indicated in Fig. 10. Similarity to actual flux patterns in Fig. 11 is readily seen.

It can be seen from Equation 12 that, if the number or values of permeance paths can be reduced, the leakage will be reduced.

To determine the leakage factor, the following formulas have been evolved.*

The three basic types of circuits to be considered first are shown in Figs. 12.1, 12.2 and 12.3. The leakage factor for each of the three types of circuits can be calculated with the following generalized equation:

$$\sigma = 1 + \frac{L_g}{A_g}\left(1.7\, U_a K_a \frac{a}{a + L_g} + 1.4\, b\, K_b \sqrt{\frac{U_b}{c} + 0.25} + 0.5\, U_c K_c \right) \qquad (13)$$

where U_a, U_b, U_c = perimeters of cross sections of parts dimensioned as a, b and c, respectively, in Fig. 12; and a, b, c = dimensions from Fig. 12.

Equation 13 is solved by substituting appropriate K factors for the particular circuit arrangement. When the part is a permanent magnet, two-thirds of its total length is used and also the K factor in this case is two-thirds.

For the three basic arrangements of Figs. 12.1, 12.2 and 12.3, the solutions to Equation 13 are:
Fig. 12.1:

$$\sigma = 1 + \frac{L_g}{A_g}\left(1.1\, U_a \frac{0.67\, a}{0.67\, a + L_g} \right)\left(1 + \frac{L_g}{a} \right) \qquad (14)$$

Fig. 12.2:

$$\sigma = 1 + \frac{L_g}{A_g}\left(1.7\, U_a \frac{a}{a + L_g} + 0.64\, b \sqrt{\frac{U_b}{c} + 0.25} + 0.33\, U_b \right) \qquad (15)$$

Fig. 12.3:

$$\sigma = 1 + \frac{L_g}{A_g}\left(1.7\, U_a \frac{a}{a + L_g} + 1.4 b \sqrt{\frac{U_b}{c} + 0.25} + 0.33\, U_c) \right) \qquad (16)$$

Equation 13 can also be extended to magnetic circuits which resemble the three basic arrangements. Fig. 12.4 through 12.8 shows these arrangements. Equations to be used are:
Fig. 12.4:

$$\sigma = 1 + 1.7 \frac{L_g}{A_g} U_a \left[\frac{e}{e + L_g} + 0.67 \frac{0.67a}{0.67a + L_g + 2e}\left(1 + \frac{L_g + 2e}{a} \right) \right] \qquad (17)$$

Fig. 12.5:

$$\sigma = 1 + \frac{L_g}{A_g}\left(1.7\, U_a \frac{a}{a + L_g} + 1.4\, h + 0.94\, b' \sqrt{\frac{U_b'}{c} + 0.25} \right) \qquad (18)$$

Fig. 12.6: A_g' = area of pole-piece frustrum; valid when $d > 2e$, $L_g > e$, and for cone half-angles from 40 to 55 degrees.

$$\sigma = 1 + 1.7 \frac{L_g}{A_g'} U_a \left[\frac{a}{a + L_g} + 0.67 \frac{0.67}{0.67a + L_g + 2e}\left(1 + \frac{L_g + 2e}{a} \right) \right] \qquad (19)$$

Fig. 12.7:

$$\sigma = 1 + \frac{L_g}{A_g}\left(1.7\, U_a \frac{a}{a + L_g} + 0.94\, b \sqrt{\frac{U_b}{c} + 0.25} \right) \qquad (20)$$

Fig. 12.8: Equation 13 is valid for ring magnets even for eccentric arrangements. For perimeter U_a,

*Equations presented here are the result of work done by Dr. R. K. Tenzer of Indiana Steel Products Co.

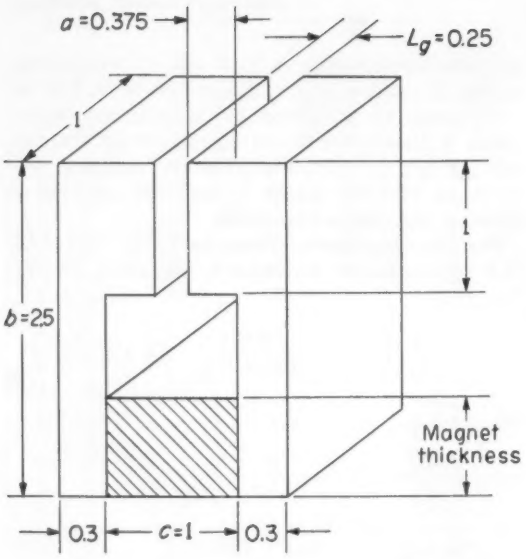


Fig. 13—Magnet configuration analyzed for flux leakage in *Example* 2.

perimeter of the gap is used, and

$$a = \frac{\pi}{6}(D + d - 2L_g)$$

$$\sigma = 1 + 1.1\frac{L_g}{A_g}U_a\frac{0.67a}{0.67a + L_g}\left(1 + \frac{L_g}{a}\right) \qquad (21)$$

Accuracy of leakage factors calculated according to Equations 14 through 21 has been checked against measured values on many different magnetic circuits. Deviations were less than ±10 per cent.

EXAMPLE 2: In Example 1 the length of magnet to produce 2000 gauss in a ¼-in. air gap has been determined as being 0.970-in. This was without allowance for the reluctance factor. For the purpose of this calculation, assume the magnet length to be 1 in. Given additional dimensions for the air gap and a construction as shown in Fig. 12.3, it is necessary to determine the cross-section of the magnet. Actual dimensions are shown in Fig. 13.

For this construction, Equation 16 would be used. From Fig. 13, $U_a = 4$ in., and $U_b = 2.6$ in.

The remaining unknown in Equation 16 is U_c. To determine U_c, thickness of the magnet must be found. The following method uses successive approximations to arrive at this thickness.

First, a value is assumed for the leakage factor. A construction as in Fig. 13 has a high leakage factor, so the first assumption will be $\sigma = 3$. Any value can be chosen, but a good guess the first time will reduce the amount of mathematics. From Equation 5,

$$A_m = \frac{B_g A_g \sigma}{B_d} = \frac{(2000)(1)(3)}{10{,}200} = 0.588\text{-in.}$$

The value $B_d = 10{,}200$ gauss is simultaneous with $H_d = 515$ oersteds for Hyflux Alnico V chosen in Example 1.

Thus, thickness would also be 0.588-in. and $U_c = 3.176$ in. This is the first trial.

This value, plus $L_g = 0.25$, $A_g = 1$, $a = 0.375$, $b = 2.5$, $c = 1$, $U_a = 4$ and $U_b = 2.6$, are substituted in Equation 16:

$$\sigma = 1 + \frac{0.25}{1}\left[1.7(4)\frac{0.375}{0.375 + 0.25} + 1.4(2.5)\sqrt{\frac{2.6}{1} + 0.25} + 0.33(3.176)\right] = 3.8$$

This new approximation of $\sigma = 3.8$ is resubstituted in Equation 5 to arrive at new values for $A_m = 0.745$ and $U_c = 3.490$. Plugging this value back into Equation 16 gives $\sigma = 3.832$.

Successive shuttlings back and forth from Equation

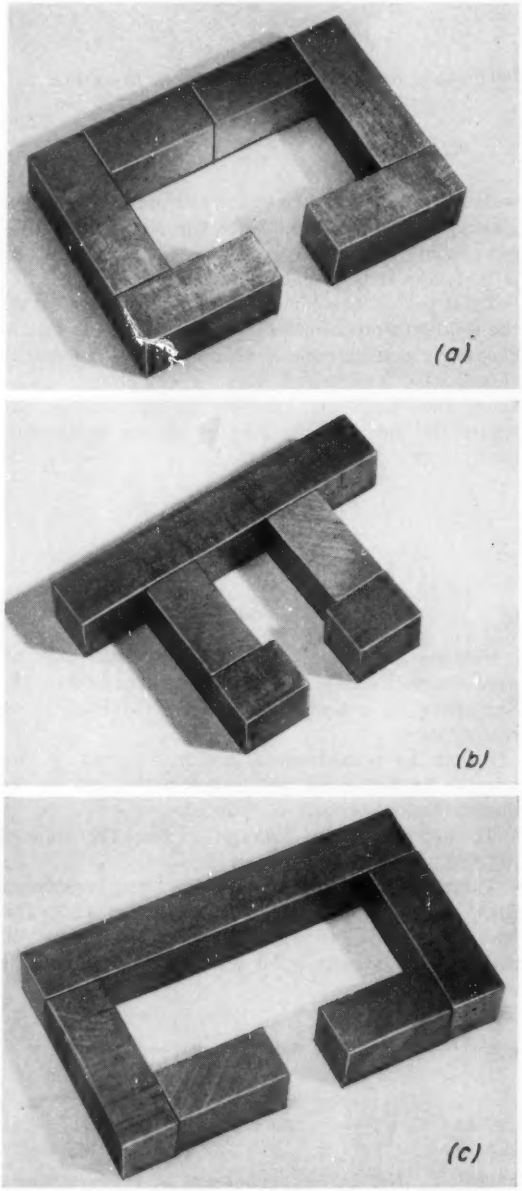


Fig. 14—Test assemblies used to determine optimum position of magnet in circuit: *a*, magnets at back; *b*, at sides; *c*, in front.

5 to Equation 16 will quickly produce a value of 0.752-in. for thickness of the magnet.

Inch dimensions can be used in the calculations because Equation 16 is dimensionless, and Equation 5 can also be arranged in dimensionless form.

Location of Magnet: The location of permanent magnets in the magnetic circuit is a factor in design. A comparatively simple experiment demonstrates the nature of changes that occur when magnets are placed in various positions in a simple magnetic circuit. These tests clearly indicate the importance of placing the magnets as close to the air gap as practical.

The basic magnetic circuit used in this experiment required that flux be produced across an air gap ½-in. long between pole faces ½-in. square, Fig. 14. To simplify the various assemblies, all cross sections of the material, both soft steel and permanent magnets, were also ½-in. square.

Three basic arrangements were investigated: magnets placed at the back, Fig. 14*a;* magnets placed on the side, Fig. 14*b;* and magnets placed immediately adjacent to the air gap, Fig. 14*c*. In all cases, the same two magnets ½-in. square by 1 in. long were used. Also, in each case the magnets were magnetized in position in the final magnetic circuits.

Importance of position of the magnets in the circuit is confirmed by the results obtained, Table 2. For example, in the Fig. 14*a* assembly a flux of 908 gauss was obtained, whereas with magnets as in Fig. 14*c* the flux density of 1975 gauss was obtained in the same air gap.

Table 2—Test Results on Magnet Assemblies

Assembly Fig.	14*a*	14*b*	14*c*
Flux density in gap, B_g (gauss)	908	1505	1975
Maximum flux density in magnet, B_m (gauss)	12,800	11,840	9450
Leakage coefficient, B_g/B_m	14.1	7.86	4.78
Working point of magnet, H_d (oersted)	290	490	558
Energy product at working point, $B_dH_d \times 10^6$	3.48	5.41	5.13
Dimensions:			
Window length	2.0	0.75	2.5
Window width	1.0	1.0	1.0
Pole piece length	1¼	⅝	None

Leakage factor σ (the ratio of total flux to useful flux) varied in this experiment from 14.1 for 14*a* to a low of 4.78 for 14*c*. This greater leakage of the Fig. 14*a* assembly is due to the fact that areas at maximum potential are much larger than those in Fig. 14*c*.

These experiments clearly indicate that the leakage factor is kept low by keeping surface area at maximum potential to a minimum. This is achieved by placing the magnets as close to the gaps as practical. Also, proximity of high potential areas affects the leakage.

These factors have been utilized in such assemblies as magnetron magnets as shown in Fig. 15. In these, efficiency is important since the permanent-magnet material represents a major portion of cost and weight. It will be noted that maximum potential is developed at the gap, and the distance between areas close to maximum potential are increased as rapidly as practical.*

Soft Steel Areas: As indicated in Equation 1, $R = L/\mu A$ and in soft steel the value of μ can vary greatly. For ordinary cold-rolled steel the value of μ at a flux density of 10,000 gauss is in the order of 2000. At 14,000 gauss, μ is 1170. At 18,000 gauss, μ is 180. At 20,000 gauss μ is 65.

It can be readily realized that it is desirable to work the soft steel at the lower flux densities since the magnet would have to be made longer for a greater length of soft steel if worked at the higher flux densities.

Joint Reluctances: Magnetomotive force required for joints is a direct function of the effective length of the gap times the flux density in the gap. In the case of Alnico V, normally designed to work in the order of 10,000 gauss, poor joints will require a certain portion of the magnetomotive force produced by the magnet. However, even with very good joints, the effect is the same as about 0.0015-in. of gap. If possible, a design should have as few joints in the circuit as possible.

Volume of magnet material required to produce a specified flux density in the gap is obtained by combining Equations 4 and 5.

$$V_m = \frac{B_g^2 A_g L_g \sigma r_f}{\mu_v B_d H_d} \qquad (22)$$

Thus, basically, the volume of material required

*Complete discussion of this subject can be found in *Applied Magnetics*, Vol. 3, No. 5.

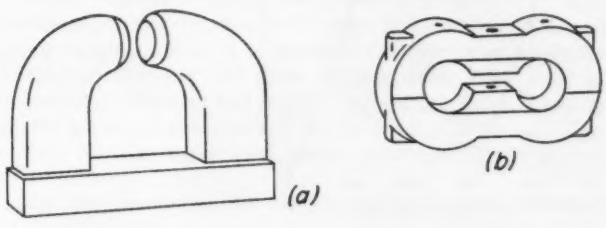


Fig. 15—Magnetron magnets, in which the magnet is placed close to the gap for maximum efficiency. A horn-shaped magnet is shown at *a*, an E-shape at *b*.

is proportional to the flux density squared. To double the flux density (B_g), four times as much permanent magnet material will be required, assuming other factors remain the same.

Variable Air Gap Designs

Many devices using permanent magnets have circuits in which the flux varies. Examples of these are magnetos, motors, generators, and holding devices. This variation of flux within the magnet may be caused by either a change in the dimension of the air gap or by an external demagnetizing force. These factors must be given consideration in the design of permanent magnets for such applications.

To illustrate the nature of flux changes which take place within the magnet in a magnetic circuit having a varying air gap, the generators shown in Fig. 16 will be used. Consider first that the magnet is magnetized in Position 1. The magnetization of the magnet will follow a normal magnetization curve as in Fig. 16 to a point B_{peak}. If there were no air gap in the circuit, the induction would return along the hysteresis loop to the point B_r.

Since there is a small gap present when the generator is in Position 1, a certain magnetomotive force will be required to overcome the reluctance of this gap. Therefore, since the magnet must produce the required magnetomotive force, the operating point will move down the demagnetization curve to point A. The vertical projection of point A to the base line indicates the magnetizing force per unit length of magnet being produced by the magnet H_a. A horizontal projection shows the corresponding reduction in flux density to point B_a.

When the generator magnet is turned to Position 2, there is an increase in the air gap, and the operating point moves to point B on the demagnetization curve. In this position the magnetomotive force necessary to overcome the reluctance of the air gap is H_d times L_m and the resulting flux density in the magnet is B_d.

Returning the magnet to Position 1 will not cause the operating point to move back up the demagnetization curve to A. It will instead, move along a new curve to point A_1. This new path that the operating point follows as the generator magnet is rotated is known as a "minor hysteresis loop." Slope of this line is known as "incremental permeability," μ_Δ. Although the slope of the minor hysteresis loop varies slightly at various portions of the curve, for purposes of estimation the slope may be considered the same as that of the demagnetizing curve at the point B_r.

Note that the value of B at point A_1 is less than that for point A on the demagnetization curve. Consequently, the flux density in the air gap will be less.

Permeance Coefficient: A line drawn from the origin of the graph in Fig. 16 through the operating point (line OA) is representative of the permeance coefficient (p) of the magnetic circuit with the magnet in position 1. Permeance coefficient is defined by

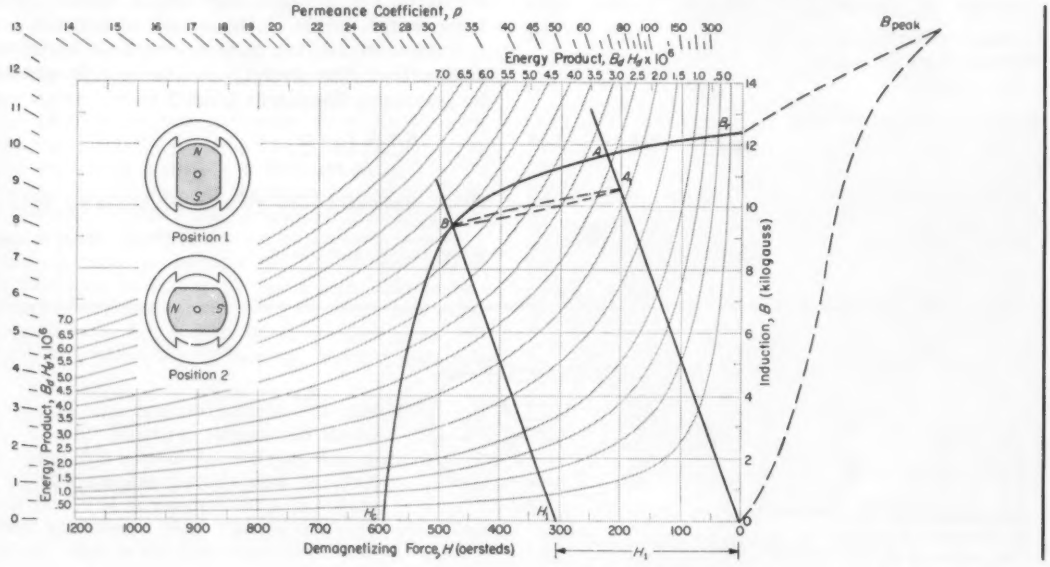
$$p = \tan AOH_c = \frac{B_d}{H_d} \qquad (23)$$

From Equations 4 and 5,

$$p = \frac{B_g L_m A_g \sigma}{H_g L_g A_m \tau_f}$$

and, since $B_g = H_g$ in air,

Fig. 16—Effect of gap variations or external demagnetizing influences on magnet operating characteristics. Minor hysteresis loop is shown from B to A_1.



$$p = \frac{L_m A_g \sigma}{L_g A_m r_f} \qquad (24)$$

which is the ratio of the total external permeance to the permeance of the space occupied by the magnet. It is important to know the permeance coefficient of magnetic circuits which are subjected to varying demagnetizing influences.

The permeance coefficient is an extremely important concept in analysis of magnetic circuits. For example, while the total value of $A_g\sigma/L_g r_f$ would be difficult to determine directly, the flux density B_d in the magnet in the circuit may often be measured. From this information and a curve of the material, the value of the permeance coefficient at that point can be determined. Thus,

$$\frac{A_g \sigma}{L_g r_f} = p \frac{A_m}{L_m}$$

or, if the gap dimensions are known,

$$\frac{\sigma}{r_f} = p \frac{A_m L_g}{L_m A_g}$$

Such information will help to indicate desirable design changes.

The permeance coefficient line can also be used to indicate the extent of demagnetizing effects, such as increase of air gap or demagnetizing fields. Even after transient conditions, the permeance coefficient remains the same. A measured drop in flux can be indicated on the permeance coefficient line, as point A_1 in Fig. 16. The slope of the minor loop, which is given for the material as incremental permeability μ_Δ, can be projected to the demagnetizing curve to determine the value of B_d and H_d during transient conditions.

Design for Variable Air Gaps: The design goal for magnets subject to demagnetizing influences such as variable air gaps is basically the same as for magnets with fixed air gaps; namely, to use the minimum magnetic material consistent with cost and application.

For most efficient utilization of the magnetic material, the design should establish the point of lowest flux density (or lowest permeance coefficient) at the peak energy product. Furthermore, the permeance coefficient at the point of lowest flux density should be approximately one-half the permeance coefficient at the point of highest flux density.

The exception to these rules is Indox, which has a demagnetization curve that is basically different from those of other permanent-magnet materials. In the case of Indox, it is possible to ignore all other conditions except the point of greatest flux density. The problem of design for circuits having varying air gaps becomes simple, for it is identical to that for the fixed air gap using the dimension in effect at the required operation. This simplification, in the case of Indox, results from the fact that its minor loop nearly coincides with the major loop.

Basically, the design for variable air gap applications requires that they be treated the same as fixed air gaps except that the resulting values for the lowest point of the demagnetization curve will be determined by the slope of the minor loop. As indicated in the previous section, the permeance coefficient is often a very valuable tool in determining the lowest operating point at which a magnet is working.

Calculations involved would be to consider first the most unfavorable condition under which the magnet is to operate—for example, the largest air gap. An operating point is picked on the demagnetization curve, perhaps the maximum energy product point. Equations 4 and 5 can then be used to determine length and area of the magnet.

Taking the most favorable condition (smallest air gap, for instance), Equation 24 can then be used to determine the permeance coefficient. Intersection of the permeance coefficient with the demagnetization curve shows initial conditions. Alternately, Equations 4 and 5 could be re-solved for the initial B_d and H_d. This point on the demagnetization curve (point A in Fig. 16) is important because it shows flux values which the magnet must initially provide, and provides a specification for initial magnetization of the magnet in the assembly.

By drawing in the minor loop from the most favorable condition to the intersection with the permeance coefficient line, the actual values of B_d and H_d effective (point A_1 in Fig. 16) would be determined.

In the case of Indox I, as previously indicated, the minor loop is essentially the same as the major loop and the most unfavorable condition does not have to be given weight.

External Demagnetizing Influences

Frequently a magnetic circuit is subjected to a demagnetizing field which may be in the form of an alternating-current field, or a direct-current field in opposition to the field of the permanent magnet. This factor must be taken into account in the design of the magnet.

If the magnetic circuit in a particular device has an air gap resulting in a permeance coefficient similar to that of the generator in Fig. 16, it would initially operate at the same point A on the demagnetization curve. The application of an external demagnetizing force causes the point of operation to move down the demagnetization curve to point B.

Magnitude of this demagnetizing force can be determined by constructing a line parallel with OA which passes through point B and is projected to the base line. The effect of the external magnetomotive force (F_d) is determined as follows:

$$H_1 = \frac{F_d}{L_m} \qquad (25)$$

where L_m is in centimeters. The operating point

will follow the minor hysteresis loop to point A_1 when the external field is removed.

There are cases where both a varying air gap and external demagnetizing forces exist. The one having the greater effect as indicated by the graphical solution must be considered during design. In some generators and magnetos, the effect of varying the air gap by removing the armature for repair may have a greater demagnetizing effect than armature reaction. Then this open-circuit condition becomes the predominant factor.

With the information available, the length of magnet required to produce a given flux density in an air gap under external demagnetizing conditions can be calculated by a variation of Equation 4 for magnet length:

$$L_m = \frac{H_g L_g r_f + F_d}{H_d} \qquad (26)$$

Magnets Without Pole Pieces

In designs which require the use of magnetic circuits that do not employ iron pole pieces, Fig. 17 can be used to determine the permeance coefficient. Permeance coefficients are determined by the dimension ratio of the bar, where the dimension ratio (L/D) is the length of the bar divided by the diameter.

For other than round bars, the dimension ratio may be calculated by dividing the magnet length by the diameter of a circle having equivalent cross-sectional area. Thus,

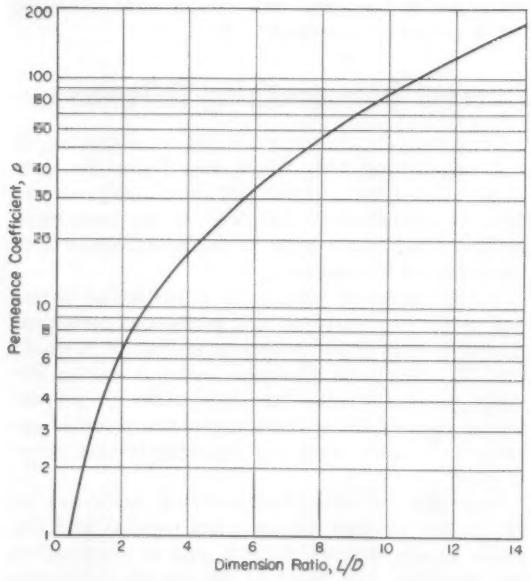


Fig. 17—Method of determining permeance coefficient from length-to-diameter ratio for bar magnets or magnets without pole pieces.

$$D = 2\sqrt{\frac{A}{\pi}}$$

where A = area of the actual section.

Flux density at the center of a bar magnet with a given dimension ratio can be determined by using the demagnetization curve of the particular material in question. The permeance coefficient is taken from Fig. 17, and a line is drawn from the origin through the indicated permeance coefficient. The point at which this line crosses the demagnetization curve indicates the flux density at the center of the bar.

Survey of Design Considerations

Thus far in this study of magnet design, consideration has been limited to obtaining the desired flux with the various magnetic materials. This assumes that the material selected can be produced in any size and shape to satisfy the design. This, of course, is not necessarily true.

A number of magnetic as well as physical properties of a magnetic material must be reviewed before it is selected for a particular application. A basic "check list" of the factors which may influence the choice of material would include:

1. Size
2. Weight
3. Shape
4. Temperature variation
5. Demagnetizing fields
6. Mechanical properties
   - A. Strength
   - B. Hardness
   - C. Expansion
7. Calibration stability
8. Cost
   - A. Material cost
   - B. Production costs
   - C. Assembly costs

These design criteria are not necessarily listed in their order of importance. Obviously, if a particular magnetic material greatly increases the cost of the end product, and it must sell in a competitive market, the device would not receive acceptance, and the design is a failure. Accordingly, other factors, such as size, weight, or shape may immediately remove a material or a particular design from further consideration.

To know if a particular material is possible—and also practical—for a proposed design, the characteristics peculiar to the various materials will be considered.

Directional Properties: Many permanent-magnet materials are isotropic; that is, they do not exhibit directional properties. These materials may be magnetized in any direction regardless of method of manufacture. Other materials, however, have much better magnetic properties in one preferred axis and are known as anisotropic materials. This anisotropic effect is obtained by manufacturing procedures.

In the case of Cunife, it is produced by drastic reduction of the size of the piece (usually by

drawing), so that the material is elongated in one direction. The material then has preferred magnetic properties in the direction of elongation.

In Alnico V or Alnico VI, the anisotropy is produced by cooling the magnet from the normalizing temperature (approximately 1300 C) to black at a controlled rate in a strong magnetic field. It is important that this magnetic field be the same, or very closely the same, as the configuration desired in the finished magnet. After this, the magnet can be demagnetized, processed in the usual way, and remagnetized.

Because of the strong magnetizing forces required and the high temperature of the material during the cooling step, there are limitations on the shape and size in which Alnico V and VI magnets can be produced. This must be taken into account during the design of a particular magnet.

Thermal Properties: Remanence of permanent magnets is temperature dependent, remanence being the induction in a magnetic circuit after the magnetic force is removed. Normally it decreases with increasing temperature and becomes zero at the Curie point, where all ferromagnetic properties vanish.

Permanent magnets in almost any practical application are exposed to varying ambient temperatures. It is often necessary to correct, compensate or allow for the temperature-dependent changes of remanence. Corrections or allowances of this kind are feasible only where quantitative data about the temperature behavior are available.

There are two different temperature effects on remanence: (1) nonreversible variations, and (2) reversible variations. Single measurements of remanence at different temperatures give results which usually contain both influnces.

NONREVERSIBLE EFFECT: Nonreversible change is the change in remanence of a magnetized magnet and its associated magnetic circuit which has been temperature cycled and returned to the original temperature (stabilizing).

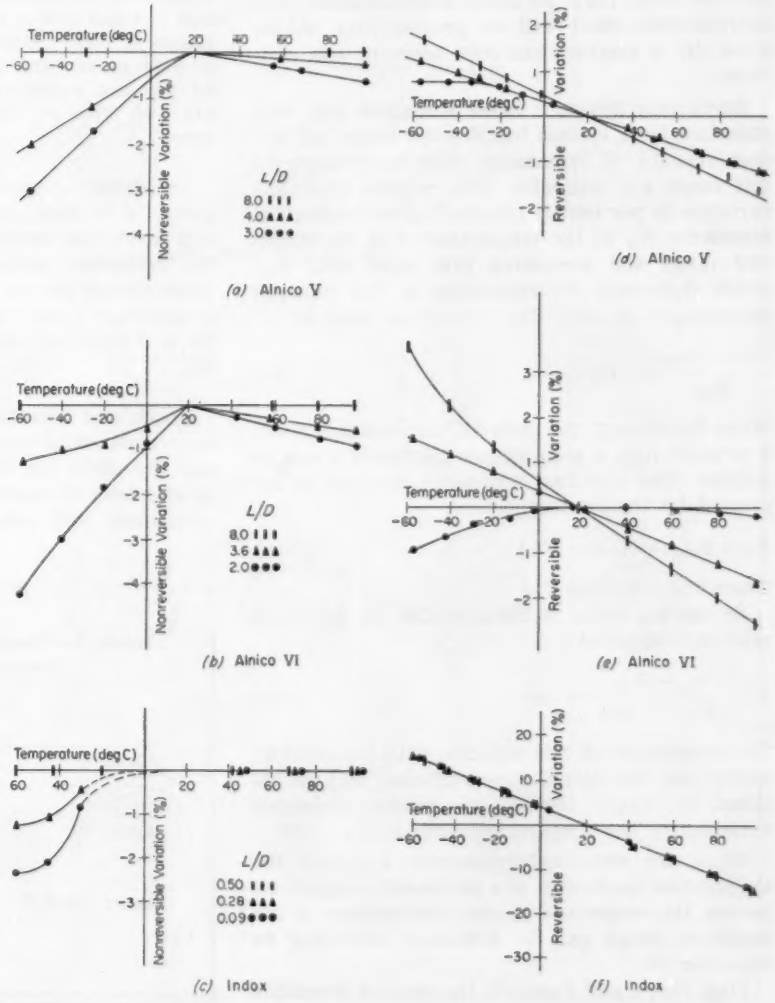


Fig. 18 — Nonreversible *(a, b, c)* and reversible *(d, e, f)* variations of remanence with temperature for Alnico V and VI, and Indox.

The nonreversible effect is connected with a loss in remanent induction. However, by remagnetizing the stabilized magnet, the initial value of induction is restored. On the other hand, the initial remanence will not be obtained by remangnetization when irreversible metallurgical changes occur in the applied temperature range. This case shall not be considered here.

Figs. 18*a*, *b* and *c* show the relative nonreversible variations in Alnico V, Alnico VI and Indox magnets, respectively. Moreover, each of these figures contains a curve showing the effect for different length-to-diameter ratios of the rod magnets. The remanence versus temperature curves without exception indicate that the nonreversible losses increase as the dimension ratio (L/D) decreases. The two Alnicos reveal nonreversible changes for temperatures below and above 20C (the magnetizing temperature), while Indox, even for $L/D = 0.09$, does not show a nonreversible effect between 20 and 100C. In other experiments, where Indox magnets are exposed to 425C after having been magnetized at room temperature, nonreversible losses of the order of a few per cent will be observed. Also, the curves of Fig. 18*c* refer to Indox material which has an intristic coercive force ($_IH_C$) of about 3000 oersteds. The nonreversible effect will be greater than shown when $_IH_C$ is smaller than 3000 oersteds, and vice-versa.

REVERSIBLE EFFECT: After a magnet has been stabilized for a certain temperature range, all further changes of remanence with temperature in this range are reversible. The relative reversible variation in per cent is obtained by measuring the remanence B_{dt} at the temperature t in the stabilized range and comparing this value with B_{d20} which represents the remanence at the standard temperature of 20C. The expression used is:

$$\frac{B_{dt} - B_{d20}}{B_{d20}} \times 100 \qquad (27)$$

When Equation 27 for different temperatures yields a straight line, a temperature coefficient α can be defined. The stabilized remanence can then be expressed by the linear function:

$$B_{dt} = B_{d20}\,[1 + \alpha(t - 20)] \qquad (28)$$

where t is in degrees C.

By solving for α in Equation 28, the following relation is obtained:

$$\alpha = \frac{B_{dt} - B_{d20}}{B_{d20}(t - 20)} \times 100 \qquad (29)$$

The comparison of this equation with Equation 27 shows that the temperature coefficient may be obtained by simply dividing the relative reversible variation by the temperature difference, $t - 20$.

When the stabilized remanence B_{d20} and the temperature coefficient of a permanent magnet are known, the remanence at each temperature in the stabilized range can be calculated according to Equation 28.

Figs. 18*d*, *e* and *f* contain the relative reversible variations of remanence evaluated according to Equation 27. For Indox these variations are inpendent of the length-to-diameter ratio of the cylinders. The curves of the Alnicos, on the other hand, reveal a steeper negative slope as L/D increases.

Notice that the Alnico VI rod for which $L/D = 2.0$ shows less than 0.1 per cent reversible change between 0 and 80C. Because of the high stabilized remanence of about 4650 gauss at room temperature, Alnico VI magnets of a corresponding operating point may be used where temperature independence is required. The Alnico V rod of $L/D = 3.0$ also reveals no reversible temperature effect between −60 and −30C.

HOW TO USE TEMPERATURE DATA: The sets of curves in Fig. 18 yield all data necessary to determine the remanence of an Alnico V, Alnico VI or Indox magnet which is exposed to a temperature in the considered range.

EXAMPLE 3: An Alnico V magnet with $L/D = 3.5$ has a remanence of 9000 gauss after magnetization at room temperature. It is intended for use in the temperature range between 20 and −30C. After stabilization, the remanence will drop about 1.5 per cent as determined by interpolation between the curves of $L/D = 4$ and $L/D = 3$ in Fig. 18*a*. The resulting remanence at room temperature has accordingly dropped to 8870 gauss. At −30C the magnet will have an 0.8 per cent higher value than at 20C according to Fig. 18*d*. Thus at −30C the remanence will be 8940 gauss.

Sometimes (especially for compensation purposes) it is more convenient to use the temperature coefficient instead of the curves which show the reversible variations. However, as some of these curves are not straight lines in the whole temperature range, the temperature coefficients in Table 3 refer only to temperatures between 0 and 80C.

Shock and Vibration: Shock and vibration have very little effect upon a material such as Alnico, and the effect can normally be disregarded. This is also true of other materials, such as tungsten, chromium, and cobalt magnet steels. Although

Table 3—Temperature Coefficients for Permanent Magnets

	L/D Ratio	Temp. Coeff. (% per deg C)
Alnico V	8.0	−0.024
	4.0	−0.016
	3.0	−0.016
Alnico VI	8.0	−0.032
	3.6	−0.020
	2.0	0.000
Indox I and V	0.5	−0.19
	0.28	−0.19
	0.09	−0.19

shock and vibration effects may be higher than in the Alnico materials, they are still small enough to be unimportant.

In these materials, repeated shocks reduce the field, but after a sufficient number of impacts the flux produced becomes stable. Unless the impacts are excessive, little or no allowance need be made. This is especially true if the magnet has been subjected to other demagnetizing effects, such as stabilization by demagnetizing fields or temperature cycling.

Mechanical Properties: The mechanical properties of magnetic materials can, at times, have a greater influence upon the design than the magnetic properties. For easy reference, these characteristics of the various magnetic materials are abbreviated in Table 1.

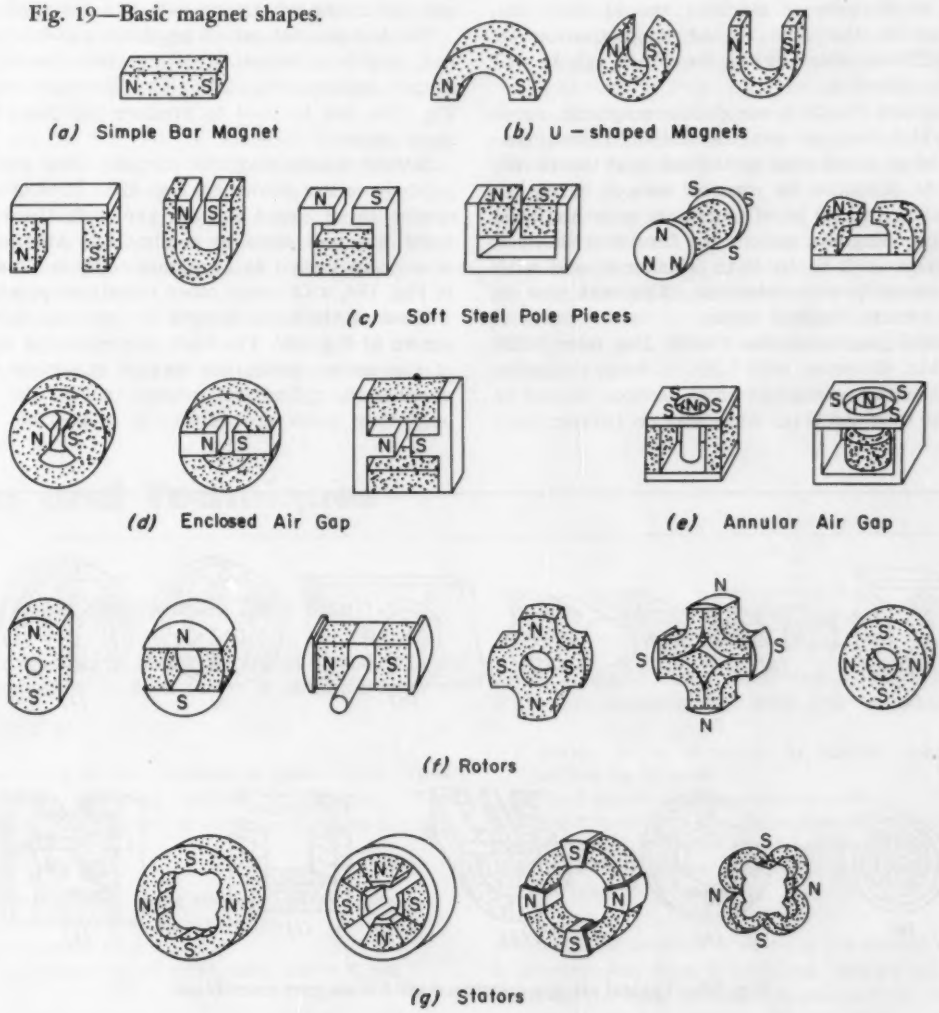
All grades of cast Alnico are produced by sand casting to the required shape. Because the material is brittle and mechanically weak, surface finishing is done by grinding—it cannot be machined. Any required holes are made by suitable cores at the time of casting.

It is often practical to introduce inserts of mild or stainless steel at the time of casting, which can be machined after final heat treatment. Although ground surfaces can be held within any practical limits, greatest economy is realized when tolerances are allowed as large as practical, even to "as cast" tolerances whenever possible. Thin sections, abrupt change of section, and sharp internal corners should be avoided, and the section around any insert should be substantial.

Sintered magnets are available in Alnico II, IV, V, VI, Indalloy, and Indox. With Alnicos, the sintering process is especially applicable to magnets of less than 1 oz. This process affords closer tolerances and greater physical strength than casting and, in some cases, inserts can be used more readily.

For these reasons, there are applications where

Fig. 19—Basic magnet shapes.



sintered magnets offer advantages even in larger sizes. Like cast Alnico, finishing must be done by grinding. Magnet shapes must be designed to permit pressing in one direction with holes or grooves parallel to the direction of pressing. Extreme variation in the section in the direction of pressing should be avoided, because the powder does not flow. The directional characteristics of Alnico V and VI should also be considered in the design of a sintered magnet.

Indalloy can be machined before final heat treatment, but grinding must be used afterwards. Indalloy magnets are limited in sizes from about 0.006 to 2 oz with the shapes having cross sections between 0.01 and 2 sq in. Cast Indalloy can be furnished, but any proposed design should be submitted to the magnet manufacturer for okay.

Indox, the new ceramic material, has many of the physical properties of other materials in the ceramic family. It is a nonconductor, hard, brittle, and lighter in weight than the metallic alloys. The same general shape limitations apply here as with pressed and sintered Alnico powders. Because Indox I is extremely difficult to magnetize, design shapes which prevent stacking should limit the dimension in the direction of magnetization to about 0.250-in. Here again, the finish can be obtained by grinding.

Cunico and Cunife I are ductile magnetic materials, which can be swaged, drawn, rolled, machined, or punched even after final heat treatment. Cunico is produced in wire or rods in sizes between 0.015 and 1.0 in. of maximum cross-sectional dimension. Magnets also can be furnished stamped from strips of 1/64 to $\frac{1}{8}$-in. thickness, and with widths variable with thickness. They can also be cast in certain finished forms.

Practical size range for Cunife I is from 0.020 to 0.250-in. diameter, with 0.200-in. being optimum. Magnets with rectangular cross sections should be no more than 0.625-in. wide and no thinner than 0.040-in. The anisotropic property of Cunife I should be taken into account when planning its use.

Basic Magnet Shapes and Air Gaps

It is common to think of permanent magnets in the form of a bar or U because these were the shapes dictated by properties of earlier magnetic materials. With newer materials that produce greater energy per unit volume, more flexibility in design is possible.

Fundamentally, for a permanent magnet to be practical, it must produce a useful magnetic field external to itself. The external magnetic field is required either in a given air gap or in a portion of the low-energy magnetic material in the magnetic circuit.

Basic Shapes: A number of basic constructions are used with permanent magnets, without pole pieces. And there are innumerable variations in almost every case. The ingenuity of the designer will determine what plan best fits his application.

The bar magnet, which produces a pole at either end, may be a round, square, rectangular or other shaped section, Fig. 19*a*. The U-shaped magnet, Fig. 19*b*, can be used to produce two poles in the same plane.

Several simple magnetic circuits using soft steel pole pieces are shown in Fig. 19*c*. It is often desirable to surround the air gap with the magnet itself or a pole piece, as in Fig. 19*d*. Another type of air gap known as an annular gap is illustrated in Fig. 19*e*, with many other variations possible.

Some of the basic designs for rotating fields are shown in Fig. 19*f*. The high coercive force of some of the newer permanent-magnet materials makes possible the cylindrical magnet in Fig. 19*f*. While only four poles are shown, it is possible to in-

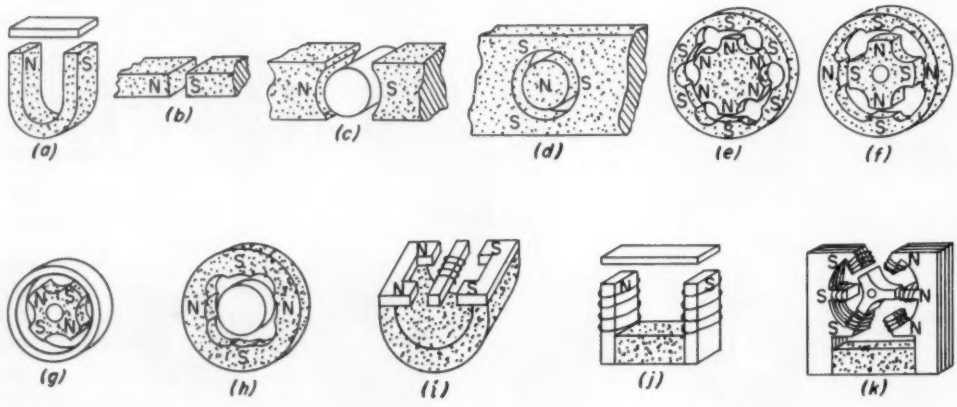


Fig. 20—Typical air-gap constructions for magnet assemblies.

corporate many poles about the periphery.

Variations of these structures in which the poles are on the inside of a ring are illustrated in Fig. 19*g*.

Basic Air Gaps: In presenting the following basic methods for obtaining flux in an air gap, no attempt is made to evaluate the relative merits of each. As in practically any other type of engineering problem, the application of the permanent magnet must be a compromise to meet all limiting factors.

A magnet of the type in Fig. 20*a* may be used to lift, hold or produce tension. This arrangement is suited to thermostats and similar control switches for providing a snap action. The benefit of "blowout" action can be obtained by placing the contacts within the field of the magnet.

Dimensions of the simple air gap in Fig. 20*b* may assume various sizes as required by the application. An air gap with a short length can be used to produce damping of a moving conducting material, such as copper or aluminum, within the gap. The eddy currents produced in the disk cause a retarding force. A similar gap, long and narrow, is used for stringed galvanometers and velocity microphones. A change in dimensions, which provides a wider gap, enables this design to be used as a magnetic separator.

The gap in Fig. 20*c* is designed for use with a moving coil designed so it rotates about the axis of the round center piece. Thus, the application of an emf will produce a rotary motion, or a rotary motion can be used to develop an emf. This type is applied to moving coil instruments, motors, and generators.

The annular gap in Fig. 20*d* is for use with a coil that can move parallel to the center pole. Here, the application of an emf will produce a linear motion, and a linear motion can be used to produce and emf. This principle is used in devices such as loud speakers, vibrators, dynamic microphones, and vibration pickups.

Variations of these two gaps are shown in Figs. 20*e* through *h*. The first of these, Fig. 20*e*, has definite areas of high flux density with intermediate portions having much lower flux density.

If a cylinder of current-conducting material is rotated or moved parallel to the center axis, eddy currents will be created and a damping action will result. This is also true of the arrangement in Fig. 20*f* which, in addition, can be used to transmit motion by attaching the inner magnet to one shaft and the outer to another.

The construction in Fig. 20*g* can be used in several ways. With a soft-steel ring as the outer portion an eddy current drive can be obtained, or a cylinder can be inserted to provide the braking action just described. A generator is obtained by adding either coils and salient poles or a distributed winding on the inside of the outer ring. A remote position indicator can be obtained by proper application of current to a distributed winding. This design can be varied as shown in Fig. 20*h*.

The devices in Figs. 20*i* through *k* differ in that these circuits permit generation of electricity or production of mechanical motion without moving either the magnets or the associated coils. When current is passed through the coil, the armature is polarized so that the degree or direction of attraction is varied, providing mechanical motion. On the other hand, changing the position of the armature alters the reluctance of the magnetic path and varies the value or direction of the flux linking the coil. This change in linkage produces an emf.

Tips and Techniques

Finding Resultant on Slide Rule

The resultant, R, of two forces, A and B, acting at right angles to each other, is obtained from

$$R = \sqrt{A^2 + B^2} \qquad (1)$$

This equation is also common in many other types of problems involving motion or distance. The usual slide-rule method of solution involves a number of steps:

1. Square value A, using slide-rule scales D and K.
2. Square value B in same manner.
3. Add squares of A and B.
4. Find square root of total, using scales K and D.

These calculations can be speeded by using an equation derived from Equation 1:

$$R = B\sqrt{\left(\frac{A}{B}\right)^2 + 1}$$

where A is the larger value and B is the smaller. With this equation, the slide rule steps become:

1. Divide larger value, A, by smaller value, B, with A on D scale.
2. Read square of the answer on scale A.
3. Reset hairline to this value plus one, on scale A.
4. Set index of C scale under hairline.
5. Read final answer on scale D under value of B on scale C.

Although the number of steps in the second method is greater, less time is required because all of the work can be done on the slide rule.—P. L. HAAGER, *assistant chief engineer, Timken Roller Bearing Co., Canton, Ohio.*

By Federico Strasser
Santiago, Chile

Design Tips for PLASTIC MOLDINGS

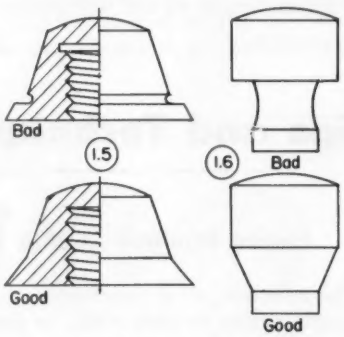
WITH moldings, the designer determines the form of the tooling. Only by considering the practical limitations of die-making can an economical part be achieved. A part which must be produced in an expensive, complicated or impractical die is an expensive part to produce. The designer must avoid thin sections, knife edges, deep holes, thin unsupported ridges or small-diameter, unsupported pins in either the part or the die. Holes and recesses on vertical surfaces require sliding die members and should be avoided. The product design must provide fast molding cycles, easy ejection from the die, and minimum susceptibility to warpage, cracking from internal stresses or damage during ejection and subsequent handling.

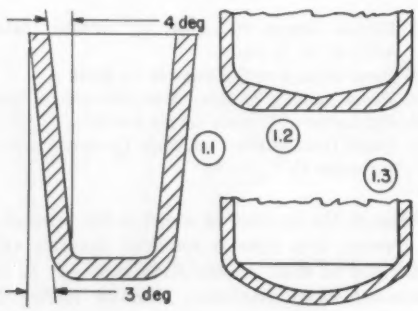
Parts produced by the plastic molding processes—compression, transfer and injection—have high surface finish, dimensional stability, and faithful repetition of fine detail. The molding processes allow incorporation of metallic inserts in the form of pins, studs, nuts or strips of metal. These inserts may act as fastening or strengthening devices, or the insert may be the important part from a functional standpoint with the plastic acting as insulation from electrical current or heat.

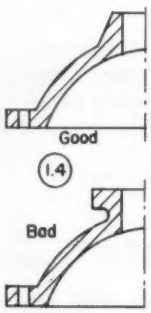
The following recommended design techniques are arranged to allow rapid comparison of details with an existing or proposed part.

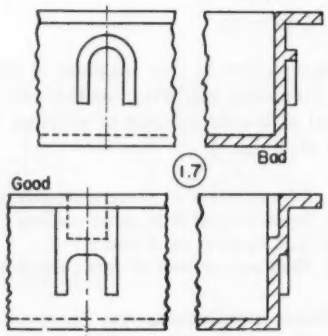
TAPER

Taper or draft is necessary on surfaces perpendicular to the die parting line to allow ejection of parts from the die. The amount of taper required will vary with the process, wall thickness, and material selected, but 3 deg is considered standard. For cup or box-shaped parts, taper of the internal wall should be greater than the external by at least 1 deg, Fig. 1.1. Warpage of large flat areas parallel to the parting line can be reduced by incorporating taper, Fig. 1.2, or designing as a curved surface, Fig. 1.3. A number of parts redesigned to include proper taper and eliminate undercuts are shown in Figs. 1.4 through 1.7.







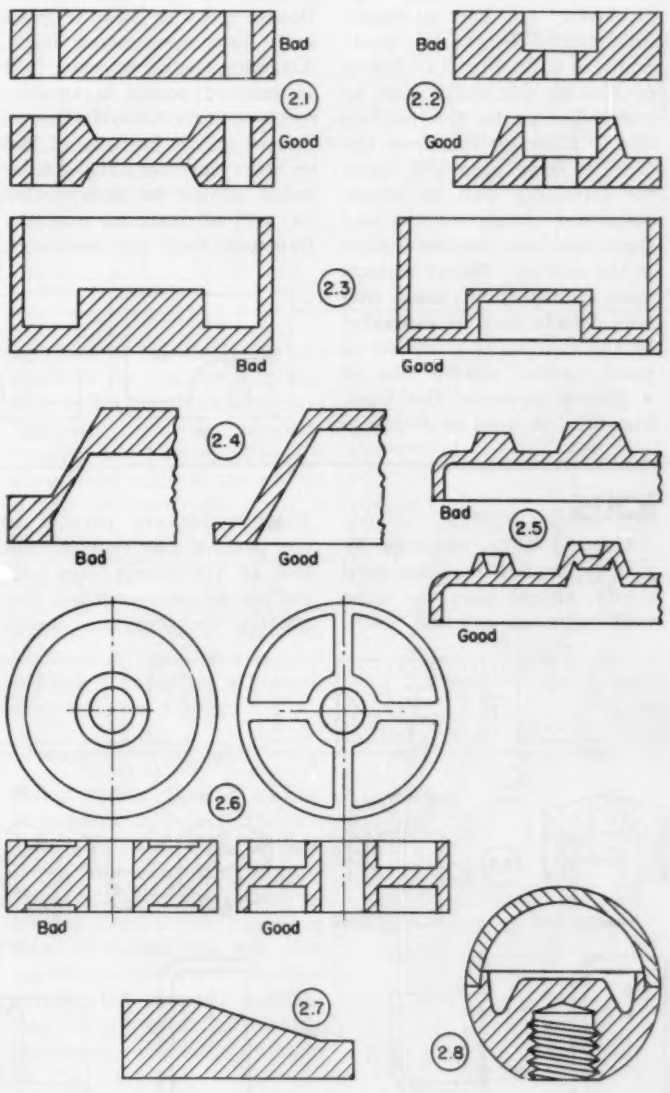


WALL THICKNESS

For economy of both material and molding time, wall thickness should be minimum consistent with required strength and depth of the part. The following are minimum wall thicknesses for compression molding; transfer and injection molding allow these values to be reduced about 0.010-in.

Depth (in.)	Wall Thickness (in.)
Up to 2	0.060 min
2 to 4	0.060 to 0.080
4 to 8	0.080 to 0.100

Curing time of thermoplastic parts depends upon the wall thickness. During curing and cooling the material contracts. For this reason, wall thickness should be kept as uniform as possible to avoid internal stresses, part distortion and cracking, Figs. 2.1 through 2.6. If changes of wall thickness cannot be avoided, the areas should be blended gradually, Fig. 2.7. Frequently design requirements will indicate assembly of two moldings if thickness variations are great, Fig. 2.8.



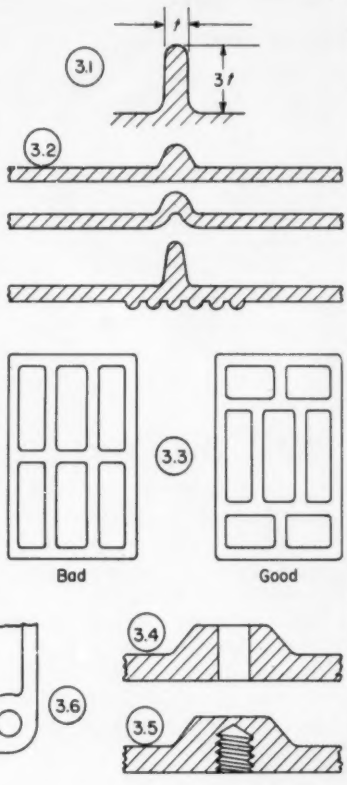
FILLETS AND RADII

All intersections of surfaces should be rounded. The radius serves both to strengthen the part and facilitate material flow during the molding process. The minimum radius is 0.020-in. Where functional requirements dictate a square edge, this minimum radius normally will not be objectionable and will reduce mold cost and improve service life of the dies.

STRENGTHENING DEVICES

Rather than increasing the wall thickness above minimum values, additional part strength may be achieved by utilizing ribs, flanges or beads. Such devices also facilitate material flow and prevent buckling and warping of the part as it cools. Thickness of the bead should be equal to or less than the nominal or average wall thickness, t. The maximum unsupported height for beads and ribs is $3t$, Fig. 3.1. Beads or ribs on side walls must be perpendicular to the parting line to allow ejection from the die. A large bead will cause the adjoining wall to hollow somewhat during cooling and flow lines are usually visible in the surface. Where appearance is important, these surface defects may be concealed by the addition of a number of small, closely spaced ribs or a groove opposite the bead, Fig. 3.2. A bead or flange is also useful to conceal or isolate the parting line from adjacent surfaces. When beads or ribs are used to reinforce a large area, their intersection should be staggered to avoid uneven shrinkage, Fig. 3.3.

Bosses are thickened areas surrounding holes, Fig. 3.4, or places where subsequent machining is to be done, Fig. 3.5. Bosses must be blended gradually into surrounding walls. Attaining proper material flow to isolated bosses is troublesome, so bosses should either be located at the juncture of two or more surfaces, Fig. 3.6, or beads should be incorporated to act as material runners. Generous radii are necessary.

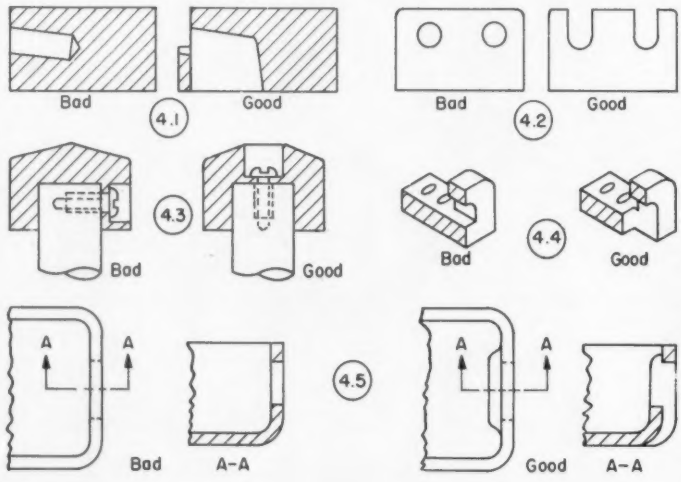


HOLES

Internal holes, produced by pins protruding into the mold cavity, should have the same wall taper as external walls. Holes which are parallel to the parting line require split dies or retractable core pins and are not recommended. Frequently the problems associated with such holes can be eliminated by redesigning them as slots or by machining the hole after molding, Figs. 4.1 through 4.4.

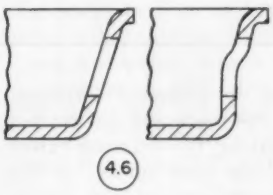
Careful design will frequently enable placement of holes in walls perpendicular to the parting line by the use of steps, Fig. 4.5, or extreme taper in the wall, Fig. 4.6. An ingenious solution to this problem is shown in Fig. 4.7.

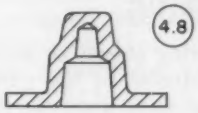
Through holes are preferable to blind holes since they allow the core pin to be supported on each end. Practical minimum hole diameters in relation to length for compression molding are: for less than 1/16-in. diam, one diameter deep; over 1/16-in. diam, two diameters deep. Any holes greater than 4 diameters long

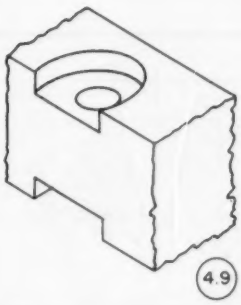


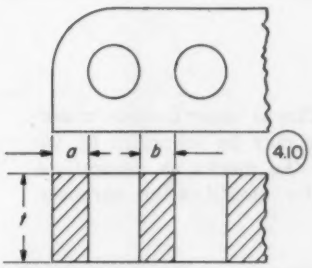
should be through holes. For transfer or injection molding, these length values may be safely doubled. Sometimes a stepped hole may be used to provide a greater depth than possible with a single-diameter hole, Fig. 4.8. If this is not possible, the length of the hole may be reduced by notching out the side wall to reduce the effective length of the hole, Fig. 4.9.

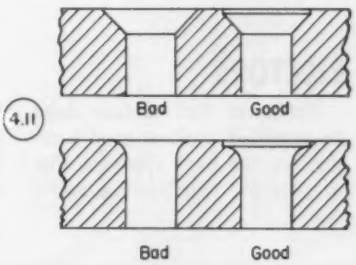
Exterior walls around holes, *a* in Fig. 4.10, should be at least hole diameter in thickness, but not less than ¼ of material thickness, and walls between holes, *b* in Fig. 4.10, should be a minimum of ¾ of the diameter thick, but not less than ⅛-in. Do not specify a perfect chamfer or radius at open end of hole. This requires prohibitive precision in the die. Leave at least a 1/64-in. vertical step at the surface, Fig. 4.11.





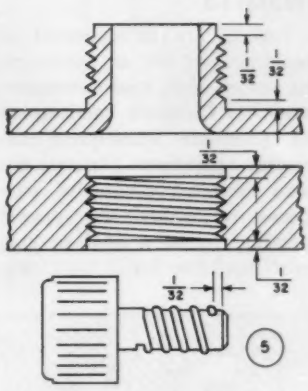






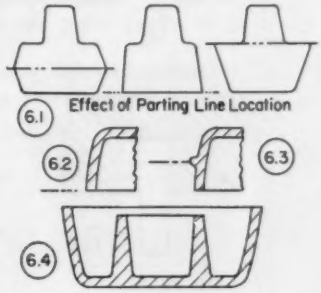
THREADS

Both external and internal threads may be molded and are used extensively in successful designs. Except for extremely coarse male threads, the axis of the thread should be perpendicular to the parting line to reduce the difficulty of trimming the flash. Where axis of thread is perpendicular to the parting line, the part must be unscrewed from the mold manually. Provision must be made in the design for the operator to secure a grasp. This is frequently done on cylindrical parts by external ridges or fluting. Threads should not come to the end of a part or completely up to a shoulder. A flat of at least 1/32-in. should be left at each end of the thread, Fig. 5. Threads of any shape may be molded down to a minimum pitch of 32 tpi. The normal minimum diameter is considered as being 3/16-in.



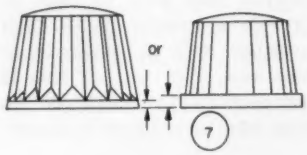
PARTING LINE

The parting line should be located properly for economical mold design, simple flash removal and easy part ejection, Fig. 6.1. It should be located at the maximum area of the part, preferably in one plane and at an edge rather than in the center of a surface, Fig. 6.2. In this case, the edge is sharp rather than a radius. If appearance is a factor, adjacent surfaces may be protected from damage during the flash trimming operation by placing the parting line on a ridge or flange, Fig. 6.3. For cup-shaped parts with internal details, the internal surfaces may be protected by making the exterior edge slightly higher, Fig. 6.4.



KNURLING

Only parallel lines should be used for knurled surfaces. The conventional diamond knurl requires split dies. The knurl pitch should be as large as possible; ⅛-in. is recommended and 1/16-in. is the normal minimum. Depth of the ribs should be very shallow. The knurling should run perpendicular to the parting line and should not extend to it. To simplify construction of the trimming die, leave at least a 1/32-in. wide flat area at the parting line, Fig. 7.

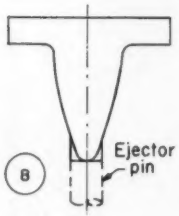


LETTERING

Lettering should be on surfaces parallel to the parting line and have generous taper at the sides of the characters. A depth of 1/64-in. is usually ample; and 3/64-in. is considered maximum. Lettering should be on flat surfaces only. Lettering on a curved surface involves split molds or complicated draft angle layout and die making. When selecting raised or depressed lettering, high die costs can be avoided by making the lettering raised from the part surface if the die cavity is machined and by depressing the lettering if the die cavity is hobbed.

EJECTORS

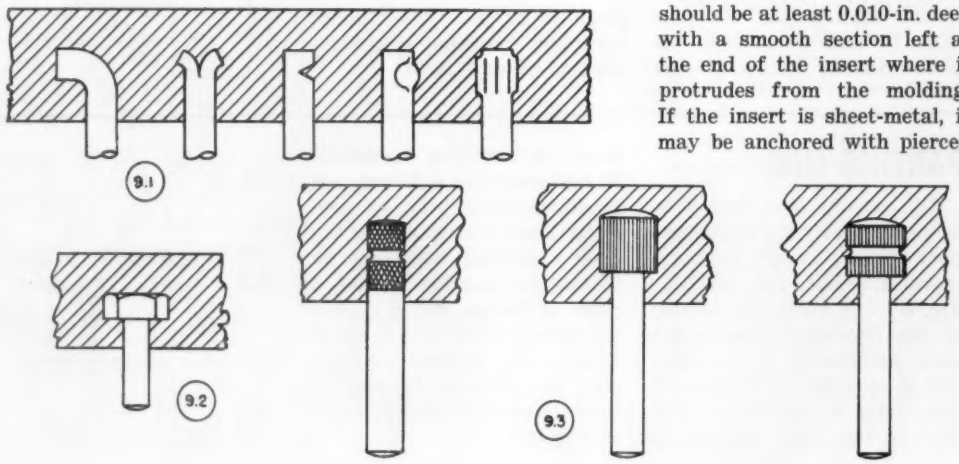
Sufficient flat surface must be provided to allow good bearing for the part ejectors, Fig. 8. Ejector pins leave a mark. If this is objectionable, markings may be concealed by using the marks as decorations or for identification purposes.



INSERTS

Inserts are incorporated in moldings to act as fasteners, to absorb high load concentrations, to facilitate handling or to eliminate subsequent assembly operations. Inserts are also used for decorative purposes or where the plastic molding forms a heat or current insulator for a functional metallic part. Because of the labor and high costs involved, inserts should be used sparingly. Inserts must be designed to have a firm anchorage in the part to prevent both rotation and pulling out. The design of the insert and its anchorage is dependent upon its nature. Simple rod inserts may be locked in place by bending, splitting, notching, swaging or knurling, Fig. 9.1. Headed parts with noncircular cross sections may require no additional anchorage, Fig. 9.2.

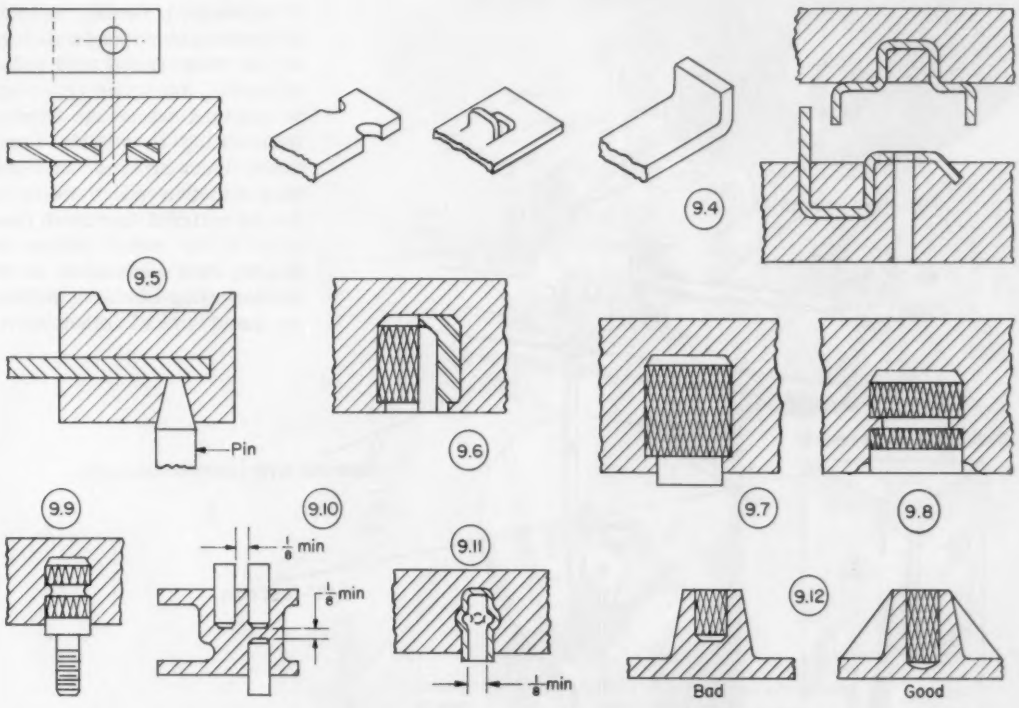
Screw-machine type inserts are commonly anchored by combinations of knurling and notches, grooves or shoulders, Fig. 9.3. Knurling on inserts should be at least 0.010-in. deep with a smooth section left at the end of the insert where it protrudes from the molding. If the insert is sheet-metal, it may be anchored with pierced



holes, notches, lanced or bent tabs or bends, Fig. 9.4. The surface of the insert may be roughened by sand or vapor blasting or pickling.

For compression molding, inserts should be perpendicular to the parting line and preferably located in the female mold. Inserts should be located so that plastic flow will force the insert into its nest in the mold rather than dislocating it. Long horizontal inserts must be supported with die pins, Fig. 9.5. The imbedded portion of bulky inserts should have well rounded or chamfered edges to facilitate material flow and avoid internal stresses, Fig. 9.6. Internally threaded inserts must be closed on one end and the external end must not be flush with the surface of the molding. If the insert end is flush, plastic material will enter the hole and require subsequent cleaning. To eliminate this, the insert may protrude, Fig. 9.7, or the surface of the material may be recessed, Fig. 9.8. For male threaded inserts, a protruding shoulder will prevent fouling of the threads, Fig. 9.9.

Due to differences in thermal expansion, plastic material surrounding metal inserts should be as thick as possible. Minimum ratio of plastic thickness to insert diameter is 3:4. Distance between adjacent or opposed inserts should be not less than ⅛-in., Fig. 9.10. Inserts which are supported by pins should have a minimum hole diameter of ⅛-in. to prevent bending or breaking of the pins under molding pressures, Fig. 9.11. Inserts in bosses should extend to within one material thickness of the opposite wall and the boss should be supported by radial ribs, Fig. 9.12.



TOLERANCES

Due to temperature changes in mold and material, tolerances should be as wide as possible. Allowance for shrinkage of the part must be designed into the mold. Wide tolerances will simplify this and materially reduce production scrap due to improper mold or material temperatures. Normally accepted tolerances are given in Table 1.

Table 1—Minimum Recommended Molding Tolerances

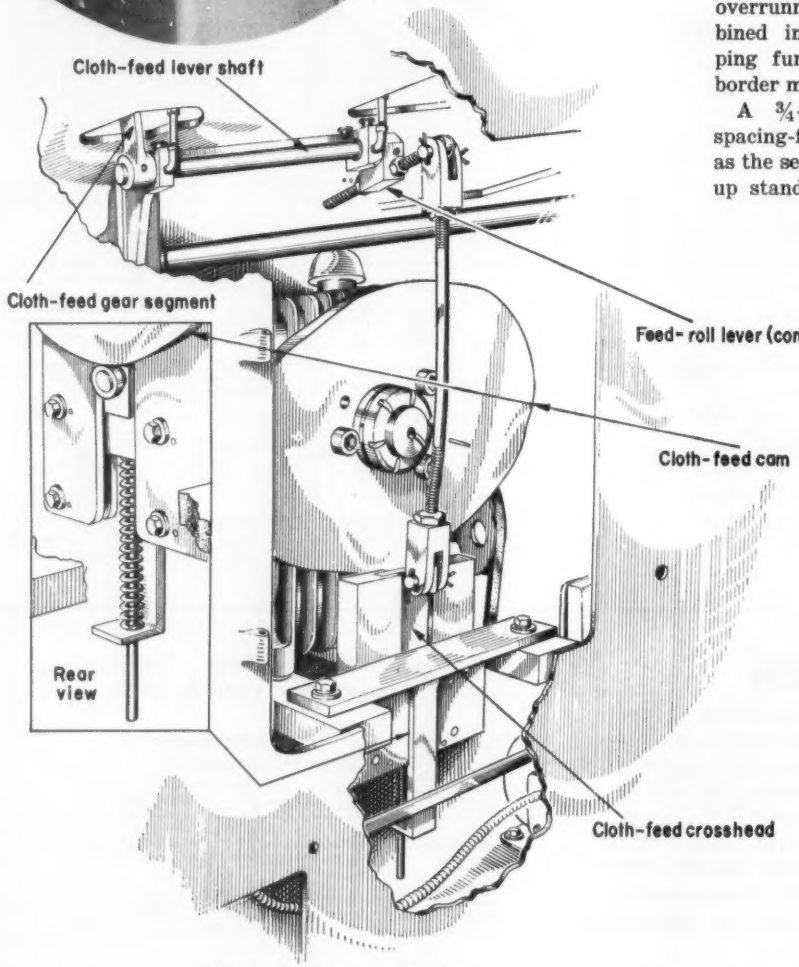
Method	Position of Surface	Tolerance (in.)
Compression Molding	Perpendicular to parting line	0.008 to 0.010
	Parallel to parting line	0.005
Transfer or Injection Molding	Perpendicular to parting line	0.005
	Parallel to parting line	0.002

Automatic Indexing Control with

Accurate, positive indexing of material fed through a mattress border stitching machine is accomplished with a rugged and precise spacing-feed mechanism. Designed and built by the United Mattress Machinery Co., the machine vertically stitches mattress borders in any width from 3½ to 10 in. Vertical flutes can be made in any width between 1⅛ to 2¼ in. apart with hems from ¼ to 1 in. wide.

In design, a Formsprag clutch is opposite mounted on each end of the front fluted feed roll. In operation, one sprag type clutch is engaged while the other is overrunning to provide a combined indexing and back-stopping function which keeps the border material taut at all times.

A ¾-hp motor drives the spacing-feed mechanism as well as the sewing machine, the wind-up stand and all other moving

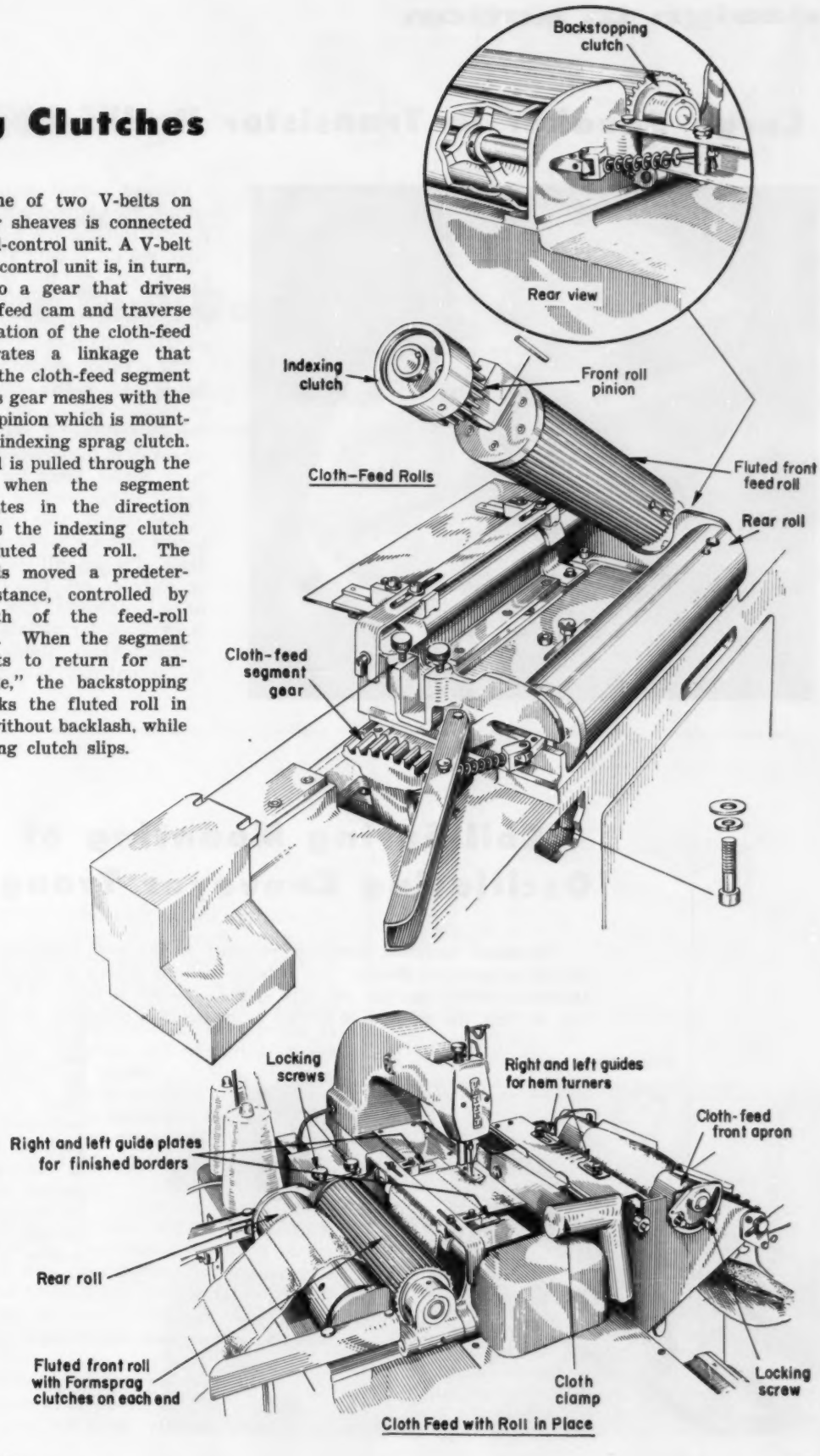


Cloth-Feed Cam and Linkage

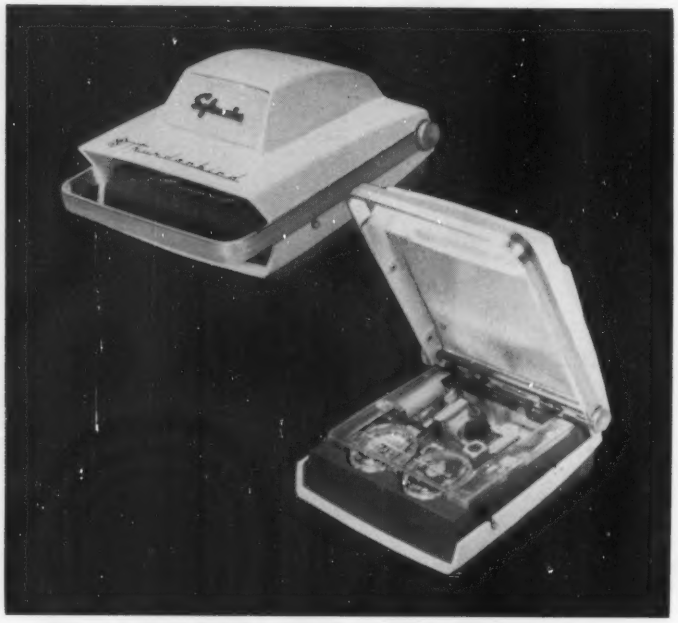
Sprag Clutches

parts. One of two V-belts on the motor sheaves is connected to a speed-control unit. A V-belt from this control unit is, in turn, coupled to a gear that drives the cloth-feed cam and traverse cam. Rotation of the cloth-feed cam operates a linkage that oscillates the cloth-feed segment gear. This gear meshes with the front-roll pinion which is mounted to the indexing sprag clutch.

Material is pulled through the machine when the segment gear rotates in the direction that locks the indexing clutch to the fluted feed roll. The material is moved a predetermined distance, controlled by the length of the feed-roll lever arm. When the segment gear starts to return for another "bite," the backstopping clutch locks the fluted roll in position, without backlash, while the indexing clutch slips.



Large Speaker in Transistor Radio Design



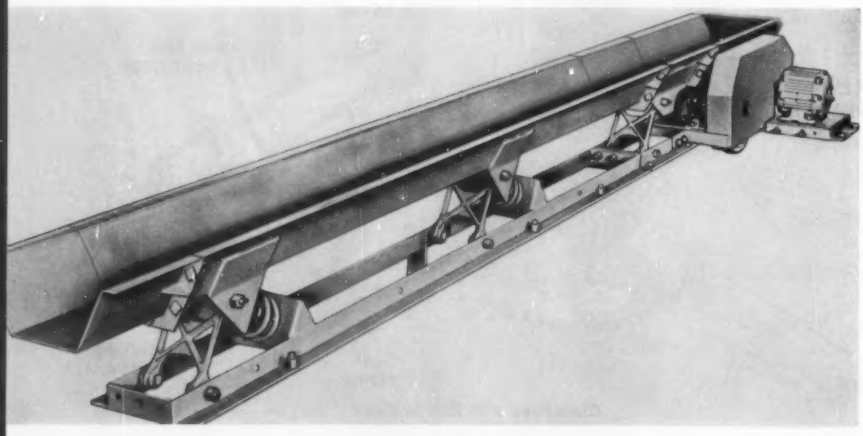
Unusual cabinet design in Sylvania's Thunderbird portable radio permits building-in a 4-in. speaker. Since the set is only 3¾ in. high, $5\frac{5}{16}$ in. wide and 6¼ in. deep, the speaker is relatively large—claimed to be largest in transistor portable-radio field.

The injection-molded plastic cabinet is made in two parts—the top or speaker section and bottom or chassis section. A safety spring, concealed in the polished-brass carrying handle, keeps the set closed tightly in the carrying position.

The circuit uses seven transistors plus one germanium crystal diode. The set will operate 500 hr on mercury cell batteries or 100 hr on inexpensive types. The radio is equipped for optional earphone listening which extends the useful life of ordinary batteries 500 hr.

Coil-Spring Mounting of Oscillating Conveyor Trough

Minimum operating power is required in the new Link-Belt Coilmount oscillating conveyor design. The material-carrying trough is supported on cast aluminum rocker legs and coil type springs. Motion is imparted to the trough and, in turn, the material is carried by means of a constant - stroke eccentric drive. The upward and forward oscillating movement provides a continuous conveying action regardless of overloads or surges. The coil springs absorb nearly all inertia forces through "natural-frequency" principles.



Finding Equations To Fit Test Data

Suggested methods for building simple formulas for relationships between properties of materials.

By A. Bruce Cox
Pittsburgh

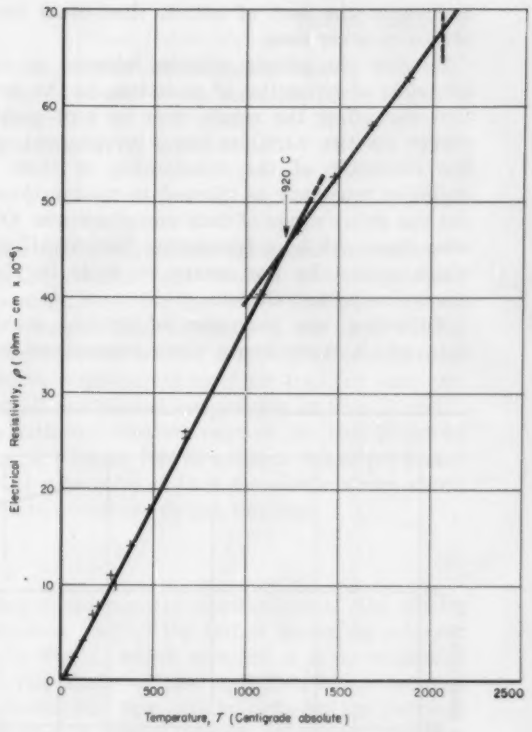


Fig. 1—Electrical resistivity of solid platinum plotted against absolute temperature. Plot suggests two phases each with a linear relationship. Data from Ref. 1.

TECHNICAL data, such as the relations between properties of materials, often can be correlated by simple equations such as polynomials with only integral powers. Studies of a variety of data on properties of materials suggest that such relations may be inherent in such data. All materials are composed of the same basic "building blocks" (protons, neutrons, electrons, etc.) in definite numbers and groupings. It is therefore not unreasonable to expect that basic properties of elements and pure compounds, at least, should be related in some such simple, integral fashion.

Practical values of finding such relationships should be readily apparent. When the basic form of the relation has been established for a particular type of data, the number of experimental points needed to construct an accurate curve of properties can be greatly reduced. The simple mathematical relationships also can be used in analysis.

In this article typical data are presented and reduced to simple equation form. The methods of plotting to bring out these relationships are sug-

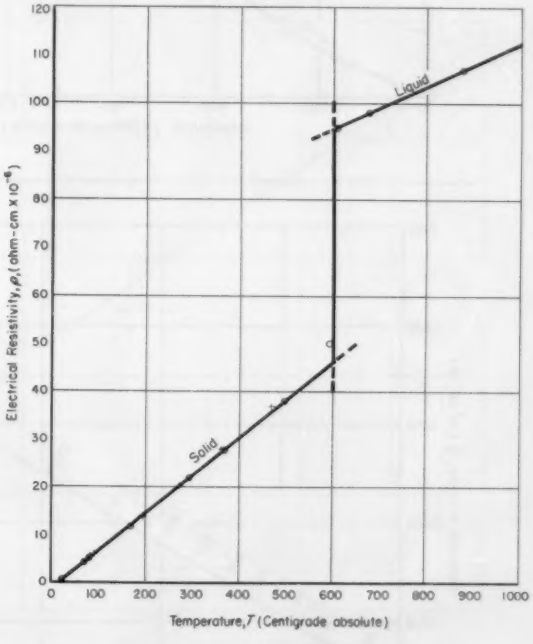


Fig. 2—Electrical resistivity of lead versus absolute temperature. Circled points are from Ref. 1. Points marked with crosses are for cold-pressed material. Wide range is covered by two linear relationships, one in the solid and one in the liquid phase.

gestive of the sort of attack that could be employed on other data.

To find the simple relation inherent in measurements of properties of materials, all the factors that can affect the result must be kept constant, except the two variables being investigated. Also, the character of the relationship of these two variables must not be allowed to change throughout the entire range of data measurements. Otherwise there will be a frustrating "empirical" result which cannot by any means be made to yield a simple, universal relation.

Following are examples of typical technical data which approximate these prerequisite conditions closely enough to make their consideration useful.

Electrical Resistance of Metals: In Figs. 1, 2 and 3 are plotted the electrical resistivities of platinum, lead and zinc vs absolute temperature.[1] The formula inherent in the data is obviously

$$\rho = a + bT \qquad (1)$$

where a and b are simple numerical constants. The linear relation holds for either solid or liquid metal, with infrequent "transitions."

Strength of Materials: Fig. 4 shows the result

1. References are listed at end of article.

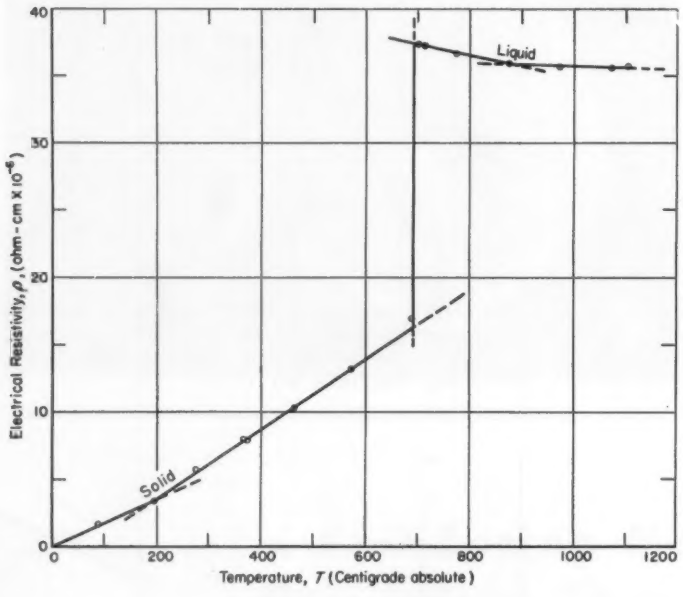


Fig. 3—Electrical resistivity of zinc versus absolute temperature. Plot suggests several phases and a linear relationship within each phase. Data from Ref. 1.

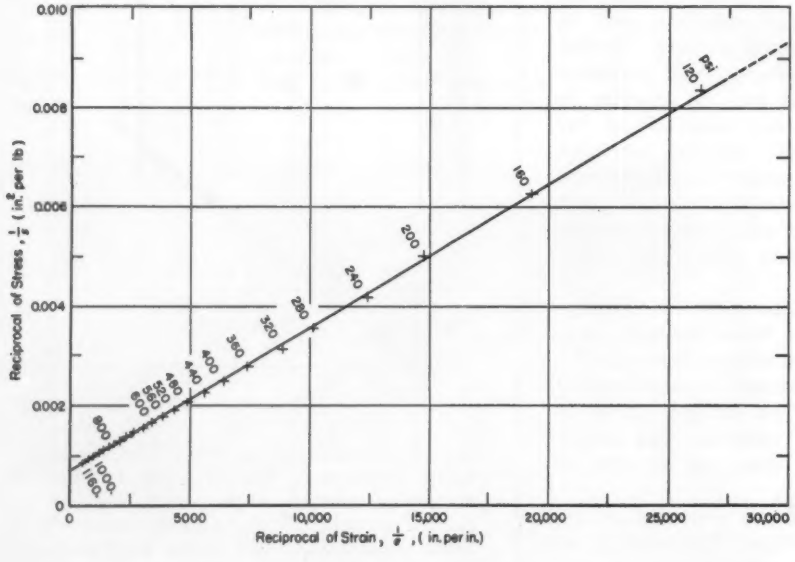


Fig. 4—Reciprocals of stress and strain for a compression test of concrete. Points fit straight line (Equation 2) with close accuracy. Data from Ref. 2.

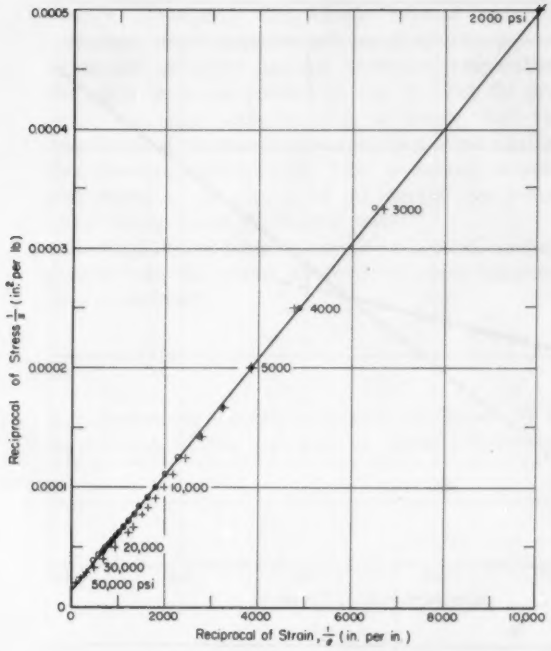


Fig. 5—Reciprocal of stress plotted against reciprocal of strain for cast iron. Circled points are for tension, crosses for compression. Deviation from straight line for either series of points is less than 15 per cent. Data from Ref. 3.

of a compression stress-strain test of concrete[2] with the reciprocal of the stress, s, plotted against the reciprocal of the strain, e. The plot is a straight line having the formula

$$\frac{1}{s} = a + \frac{b}{e} \qquad (2)$$

where a and b are simple numerical constants.

Fig. 5 presents both tension and compression stress-strain tests for cast iron.[3] This plot yields a single straight line, Equation 2, for both tension and compression, with a fair degree of accuracy.

Tension stress-strain tests for 0.42 per cent carbon steel[2] are plotted reciprocally in Figs. 6 and 7. The elastic deformation part of the test is shown in Fig. 6. Again the formula is Equation 2, but constant a is zero, so that for elastic stress-strain the relation reduces to the familiar

$$e = \frac{s}{E} \qquad (3)$$

E being approximately 30,000,000 psi. The plastic deformation part of the test is shown on a larger scale in Fig. 7, where constant a is by no means zero. The shape of the transition curve between the elastic and the plastic deformation portions of the plot is always largely dependent upon the time variable, to which little attention is usually given.

Results of tension stress-strain tests for alumi-

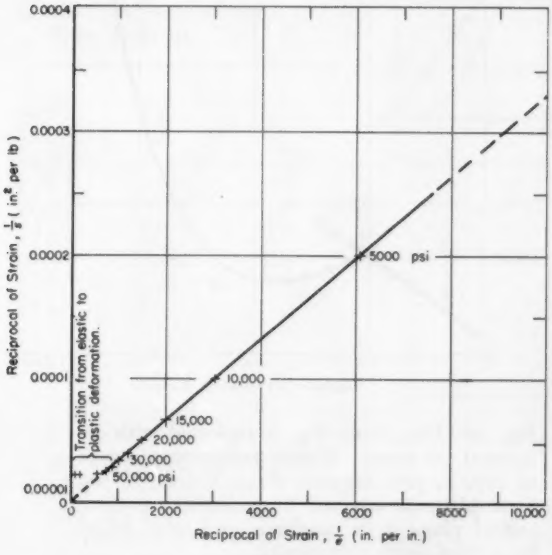


Fig. 6—Reciprocal of stress plotted against reciprocal of strain for a medium-carbon steel in the elastic range. Plot is a straight line through zero, indicating that stress versus strain would also be linear. Data from Ref. 2.

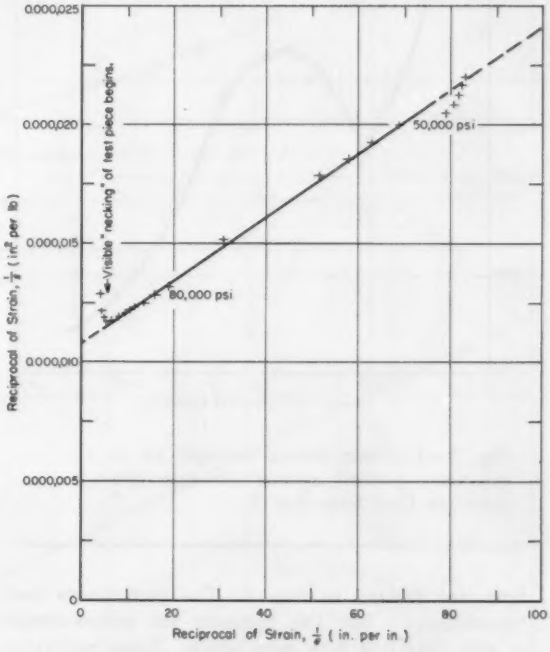


Fig. 7—Extension of Fig. 6 enlarged to show plot in the plastic range. Straight-line plot does not go through zero, hence direct stress versus strain is not linear.

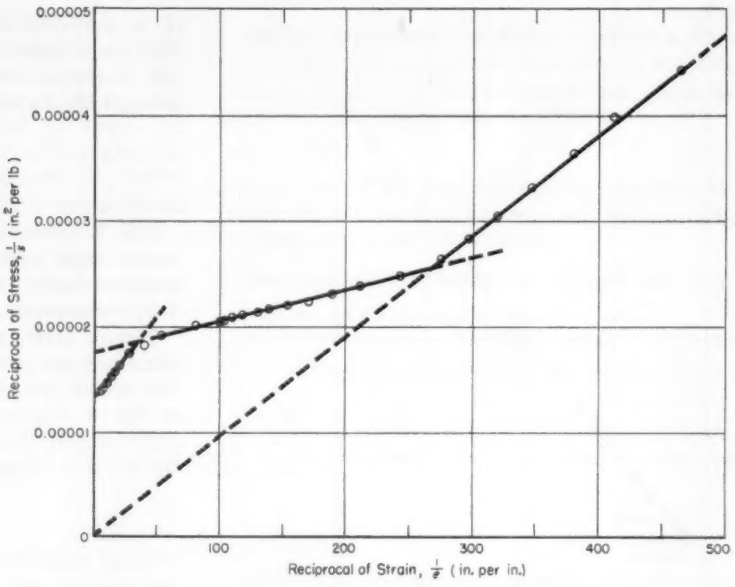


Fig. 8—Reciprocal stress-strain plot for 2024-T4 aluminum in tension. Plot suggests three distinct phases, each represented by a different linear relationship. Data, courtesy of Alcoa.

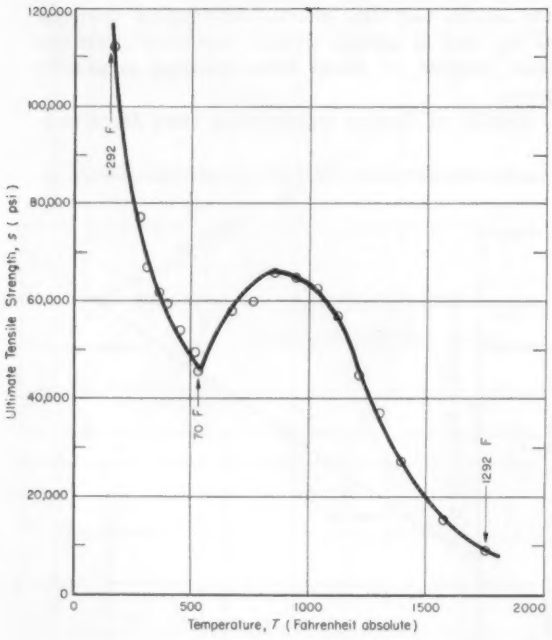


Fig. 9—Ultimate tensile strength of ingot iron plotted against absolute temperature. Data from Ref. 5.

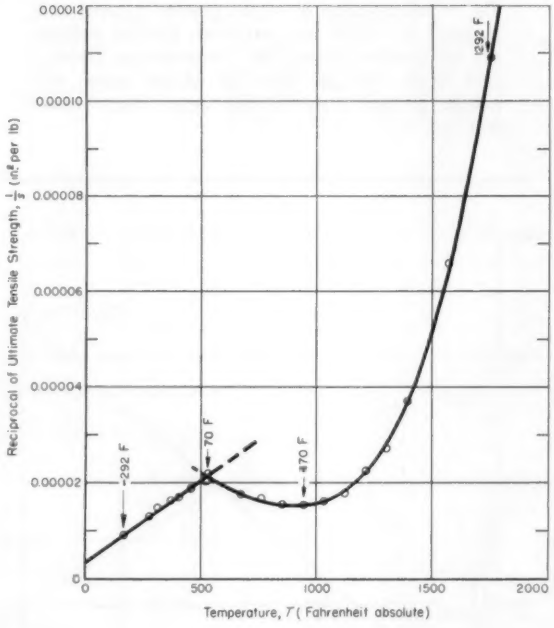


Fig. 10—Data from Fig. 9 replotted with reciprocal of stress. Within temperature range to 1292 F, plot suggests three distinct phases. First phase is covered by a linear equation, second phase by a quadratic and third phase by a third-order polynomial.

num are plotted in Fig. 8. The plot shows two "transitions," but the formula for stress-strain is still Equation 2 in each phase. Some materials may have more than the maximum two transitions so far encountered, and some, such as cast iron, Fig. 5, possibly have no transitions.

Strength and Temperature: Data on this relationship appear to be typically alike for all materials, whether ductile or not. Detailed figures for ductile metals will no doubt need some correction when data adequate to put the results on a "true" basis become available. However, the uncorrected results are sufficiently informative to

justify presenting this single typical example.

Conventional (uncorrected for ductility) values[5] of tensile strength against absolute temperature for ingot iron are plotted in Fig. 9. Fig. 10 presents the same data as Fig. 9 except that the reciprocal of the tensile strength is plotted against the absolute temperature. This peculiarly shaped plot seems to be typical of all metals, the differences being those of degree only.

In Fig. 10 the formula for the range of temperatures from the lowest available to room temperature is obviously

$$\frac{1}{s} = a + bT \qquad (4)$$

A polymorphic transition occurs at about 70 F. Application of the calculus of finite differences[6] shows the formula to be

$$\frac{1}{s} = a + bT + cT^2 \qquad (5)$$

for the range of temperatures from 70 to 470 F, where a second transition occurs. For the temperature range from 470 F to the highest available for checking, the calculus shows the formula to be

$$\frac{1}{s} = a + bT + cT^2 + dT^3 \qquad (6)$$

Specific Heat of Solids: Specific heat varies widely for different substances, and for different temperatures of the same substance, as can be seen from Fig. 11, which plots atomic heat capacity against absolute temperature for alumi-

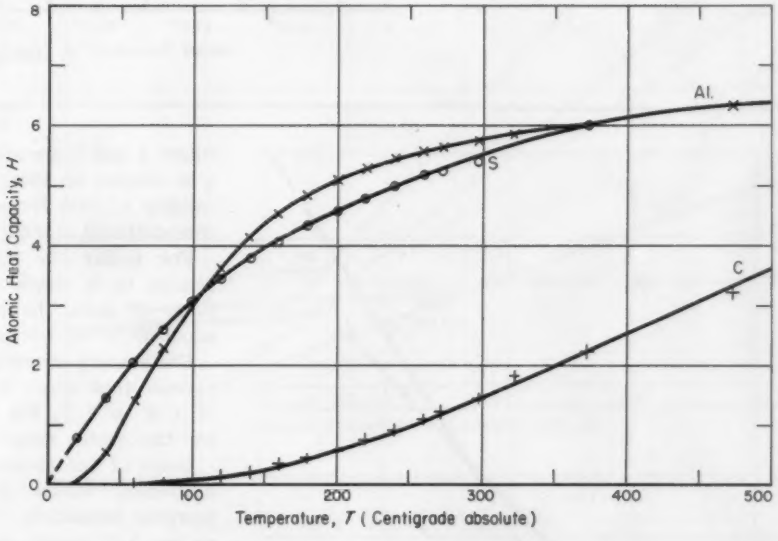


Fig. 11—Atomic heat capacities of three elements plotted against absolute temperature. Data from Ref. 7.

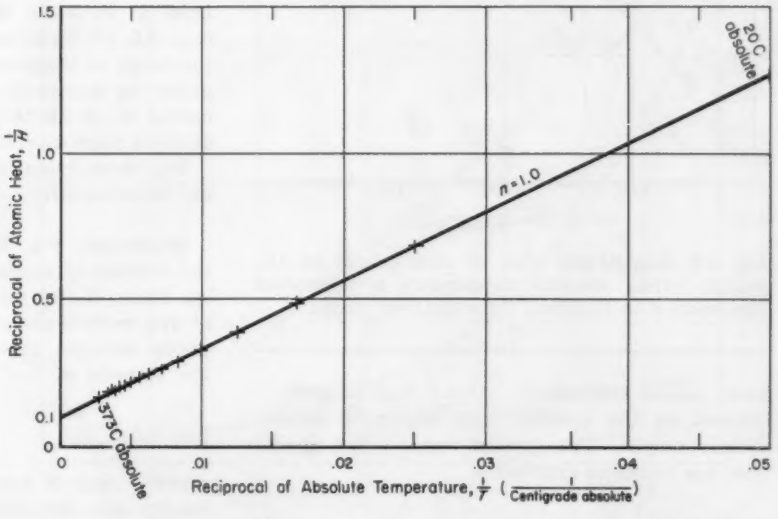


Fig. 12 — Reciprocal plot of atomic heat and absolute temperature for sulfur. Straight-line relationship indicates $n = 1$ in Equation 7.

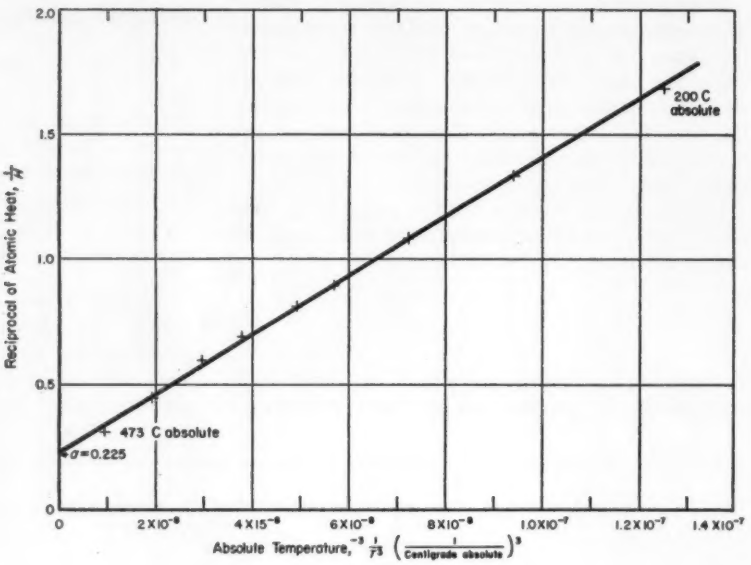


Fig. 13 — Reciprocal plot of atomic heat and the cube of absolute temperature for carbon. Plot verifies that $n = 3$ in Equation 7.

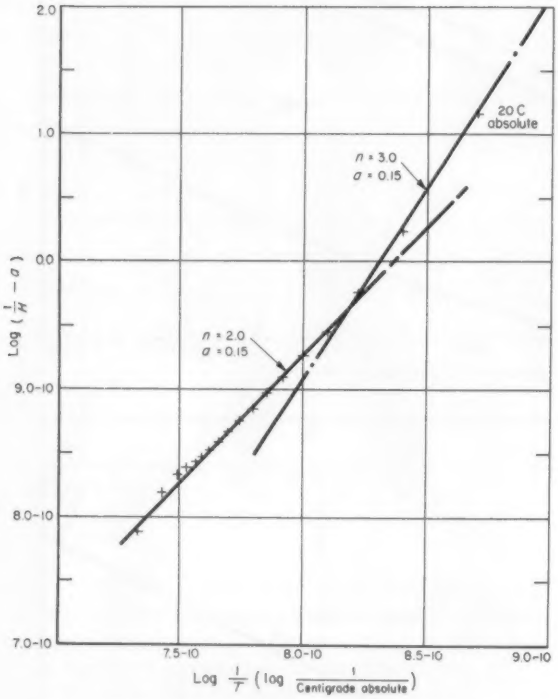


Fig. 14—Logarithmic plot of atomic heat of aluminum versus absolute temperature to determine exponents n in Equation 7 for the two phases.

num, carbon and sulfur.[7] Atomic heat capacity is defined as the specific heat multiplied by the atomic weight. The general formula for specific heat is a two-term expression,

$$\frac{1}{H} = a + \frac{b}{T^n} \qquad (7)$$

where a and b are simple numerical constants, and n is always an integral exponent, 1, 2 or 3. The validity of this formula for the three elements is demonstrated in what follows.

For sulfur the plot of $1/H$ vs $1/T$, Fig. 12, results in a single straight line for the entire range of data, the slope of the line yielding the exponent $n = 1.0$ for Equation 7.

Preliminary investigation of the data for carbon reveals that $n = 3.0$ for Equation 7. The plot of $1/H$ vs $1/T$, Fig. 13, confirms this conclusion for the entire range of data.

Some of the metals—such as silver, copper and aluminum—exhibit the typical phenomenon of polymorphic transition. The plot of log $(1/H - 0.15)$ vs log $1/T$ results in two straight lines, Fig. 14, which make a distinct angle to each other. The slope of the straight line for the temperature range from $T = 20$ to 60C absolute yields exponent $n = 3.0$ for Equation 7, and the straight line for the range of temperatures from 80 to 473 absolute yields the exponent $n = 2.0$. Additional data are needed to check the relations between 80 to 473 absolute more carefully.

The three types of relations in Figs. 12 to 14 are representative.

Magnetism: Fig. 15 shows a plot of data[8,9] for the relation of magnetic intensity, B, to magnetizing force, H, for certain temperatures. This plot of the reciprocals of the cube root of B and H yields straight lines with sudden "transitions." The formula is

$$\frac{1}{B^{1/3}} = a + \frac{b}{H^{1/3}} \qquad (8)$$

where a and b are simple numerical constants. Similar data for other steels yield similar plots—normally with two transitions. For a complete

hysteresis loop,

$$\frac{1}{B^{1/3}} = \pm \left[a + \frac{b}{(H \pm c)^{1/3}} \right] \quad (9)$$

where c is the value of H at $B = 0$. This relation seems to be valid not only for ferrous metals, but also for alloys containing little or no iron.

Creep Strength of Materials: Fig. 16 plots values of "creep" of steel[10] vs the fourth root of time. The tangent to this curve at $t = 0$ yields the first two terms of the creep relation as

$$e = a + bt^{1/4} \quad (10)$$

where a and b are simple numerical constants. For convenience, the difference between the curve and the tangent line is called Δe. The plot of log Δe vs log $t^{1/4}$ yields a straight line (also shown in Fig. 16) with slope $n = 4.0$. The complete

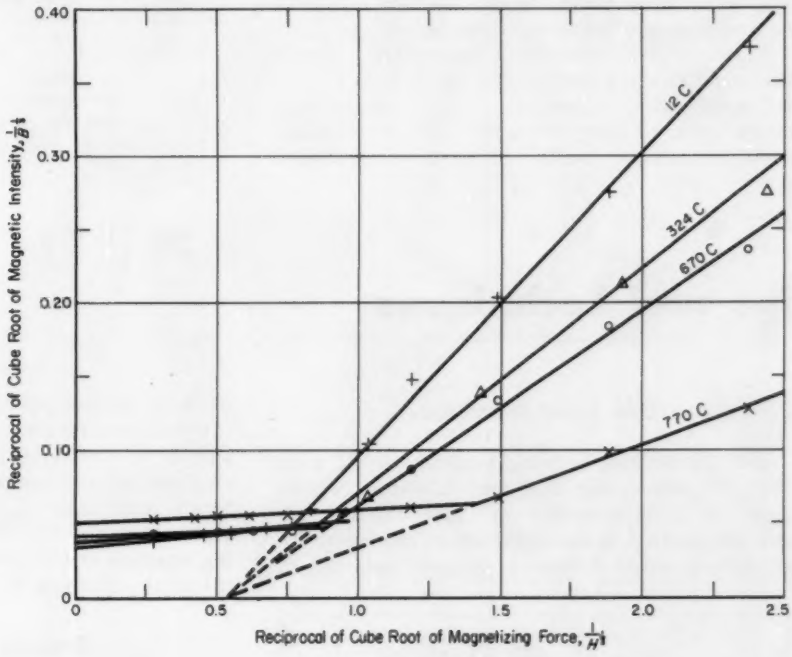


Fig. 15 — Reciprocal cube root plot of magnetic intensity versus magnetizing force for annealed wrought iron. Function is of the form indicated in Equation 8, with two distinct phases.

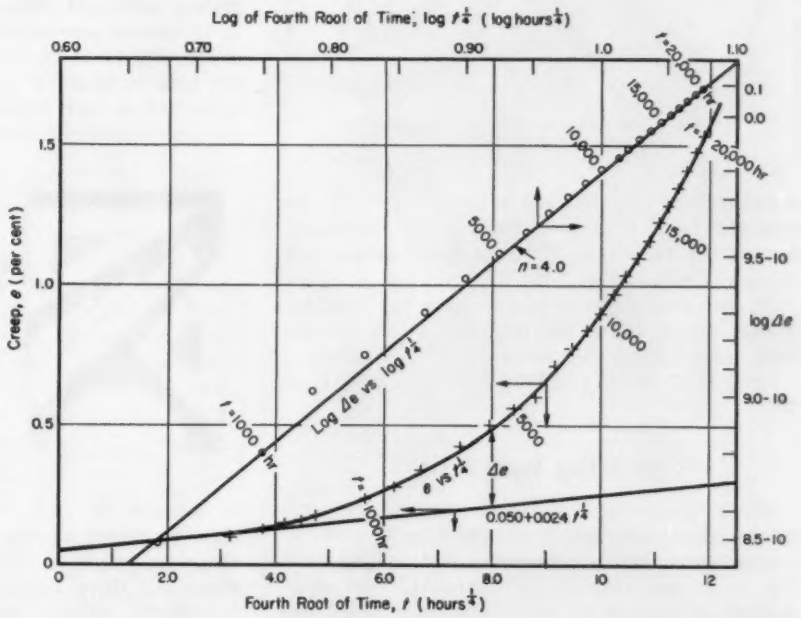


Fig. 16 — Creep of 0.35 per cent carbon steel at 850 F and 7500 psi plotted against fourth root of time. Log-log plot of Δe and $t^{1/4}$ yields a straight line, indicating a function of the form of Equation 11.

creep formula is therefore

$$e = a + bt^{1/4} + ct \qquad (11)$$

where c is a simple numerical constant. Analysis of other creep tests indicates that this formula is typical.

Conclusion: Following are tentative rules for finding simple relations that may be inherent in technical data:

1. In measuring technical data for this purpose, keep substantially constant all factors that can affect the final result except the two variables (x and y on a plot) being investigated.

2. Reduce the variables to linear form. Where the variables are already linear (as in Figs. 1 to 3) no modification is necessary. Take square root of an area variable; the cube root of a volume variable; and the fourth root of a time variable.

3. Plot the two variables either direct or reciprocally as may be necessary to have each coordinate of the plot increase as the other increases. For example Figs. 1, 2 and 3 employ a straight plot of x and y; but in stress-strain, the reciprocal plot, Figs. 4 to 10, finds the simple relation more easily even though the straight plot does meet this condition.

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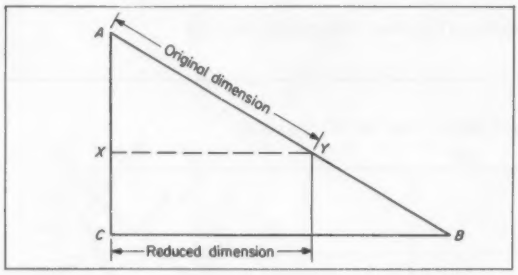
Tips and Techniques

Odd Scale Dimensions

When a drawing is being made to an odd scale that does not readily lend itself to mental calculations, a bit of geometry will speed up the job. A triangle, *ABC*, is laid out on graph paper with *AB* equal to a unit at full size or original scale and *BC*



equal to a unit at the odd reduced scale. To obtain the reduced scale length for any dimension, lay out the dimension, *AY*, on *AB* and measure the reduced dimension at *XY*.

If the new scale is larger than the original, merely assign *BC* to the original, *AB* to the new scale, and reverse the procedure when measuring. —LYLE C. RIDGEWAY, *Kiekhaefer Corp., Oshkosh, Wis.*

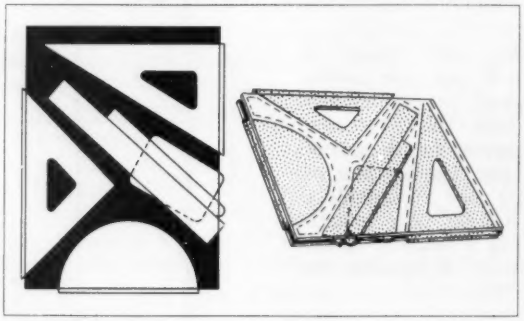
Correcting Sepia Prints

When changes or corrections are made on sepia prints with correction fluid, the area treated becomes lighter in color than the surrounding area. The fluid also softens the texture of the paper, making it difficult to produce a dark pencil line which will blend well with the rest of the print when the sepia is reproduced.

By placing the area to be corrected and redrawn over a hard material, such as a triangle or piece of glass, greater pressure can be used and dark pencil lines achieved. Reproductions made from sepias corrected this way will have as good reading qualities at the corrected area as elsewhere on the print.—ANDREW W. RASTORGUEYFF, *Utica*, N. Y.

Drafting-Tool Holder

This cardboard case keeps drafting aids together, protected from damage, and allows them to be carried conveniently. Three heavy cardboard sheets, 8½ by 11 in., are used. Arrange the drafting aids on sheet of cardboard to best utilize the space and so each projects beyond the edge to permit insertion and removal. Cut away the space to



be occupied by each item, leaving the separating core, as shown shaded in the sketch. Trace this shape on one of the outer sheets as a guide, and staple all three together as a sandwich.—W. S. MATTHEWS, *product engineering, General Motors Corp., New Departure Div., Bristol, Conn.*

A Modified Geneva Drive for SMALL INDEXING MECHANISMS

By Sigmund Rappaport*
Project Supervisor
Ford Instrument Co.
Div. of Sperry Rand Corp.
Long Island City, N. Y.

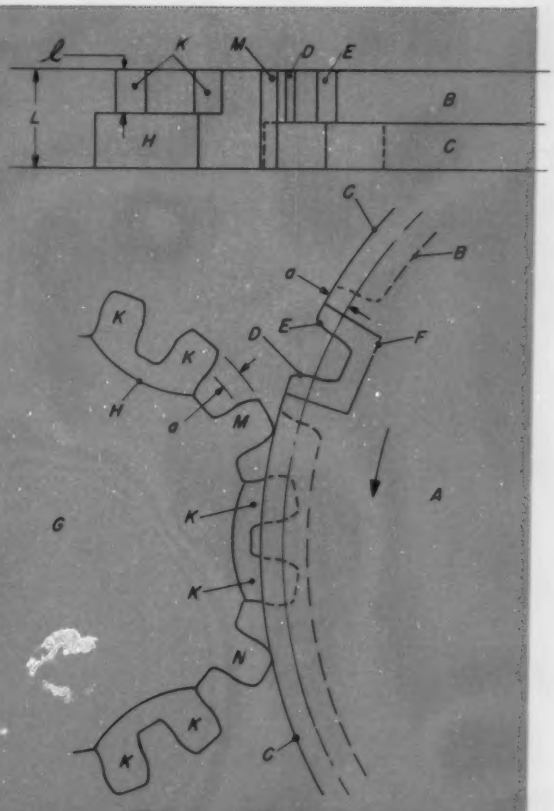


Fig. 1 — Mutilated-tooth indexing drive of a type used in instrumentation.

SMALL indexing mechanisms such as those used in instrumentation customarily employ the principle of the "mutilated-tooth" drive to achieve the desired, necessary intermittent motion. This drive, however, has some inherent disadvantages which will be discussed. This article describes a method which obviates these and which has successfully been applied in instrument design.

The mutilated-tooth drive is depicted schematically in Fig. 1. The driving member, or input *A*, consists of two concentric disks, *B* and *C*. The disk *B* is essentially a spur gear, from which all teeth except one (or more) have been removed. (In Fig. 1 two teeth have been left intact, *D* and *E*.) The diameter of the disk *C* (or locking disk) is the same as the outside diameter of the virtual spur gear *B*, or slightly larger. There is a clearance slot *F* in the locking disk, whose purpose will be shown presently.

The driven gear *G* (or "mutilated pinion") is a spur gear of the face width *L*, but it bears cutouts or mutilations *H*, which reduce the face width

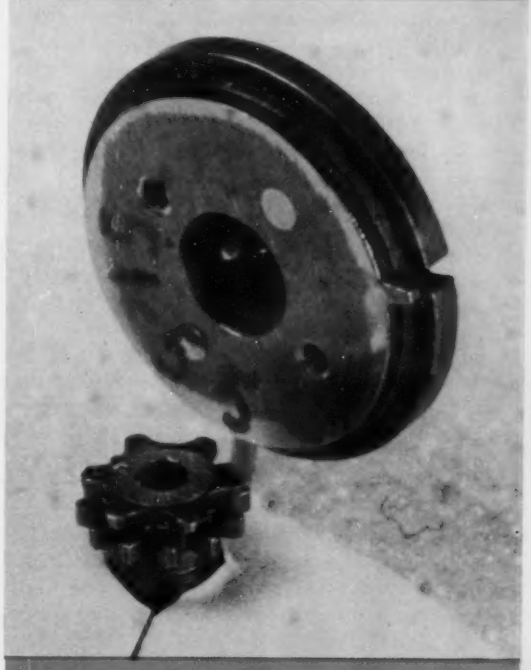


Fig. 2—Components of a one-tooth, mutilated-tooth drive.

*Also adjunct professor of kinematics, Polytechnic Institute of Brooklyn.

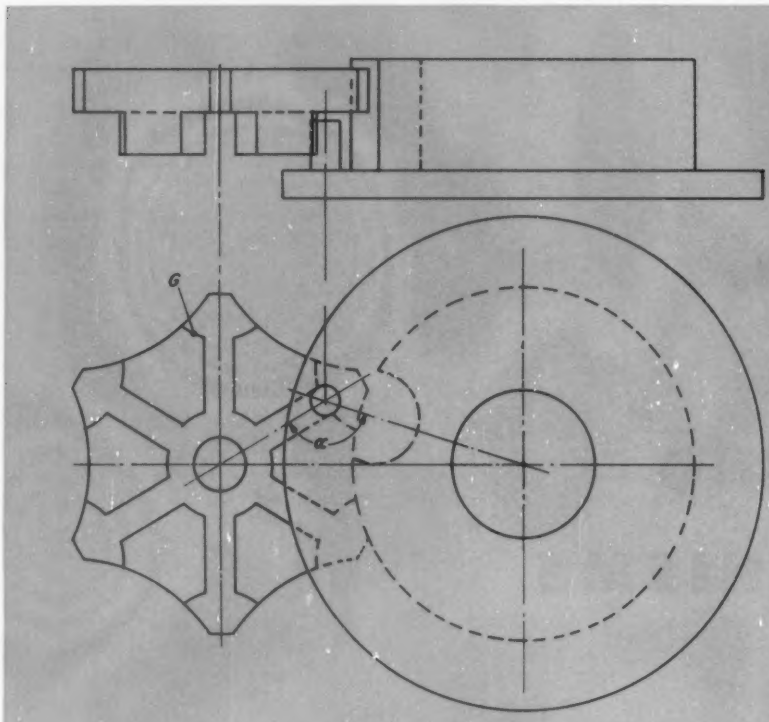
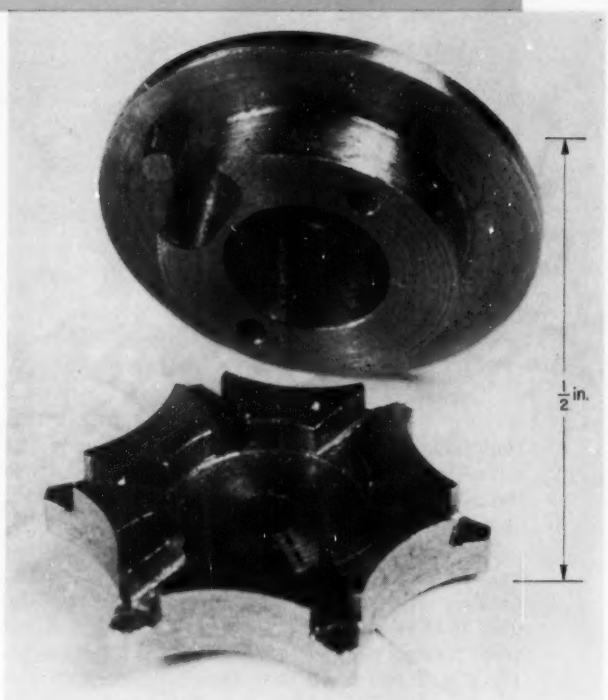


Fig. 3 — Left — Schematic of a modified geneva drive.

Fig. 4—Below—Components of a modified geneva drive.



of some of the teeth K from L to l. The intermediate teeth M and N maintain their original face width L.

In the position shown in Fig. 1, the pinion G remains motionless even though A turns. Gear G is positively locked because the contact of teeth M and N with disk C prevents it from turning. Finally the leading edge of tooth D makes contact with the mutilated tooth K, and G starts turning, causing M to engage the tooth space between D and E. The clearance slot F makes this possible without interference with disk C. The motion of G is continued until M arrives in the position initially occupied by N. Then G stops again, is locked in position, and the sequence of events is repeated after one full revolution of the driver A.

The addenda a of both gears A and G must be made smaller than standard, in order to enable tooth D to slide into contact with tooth K without interference by tooth M.

The need for this condition becomes particularly apparent if gear G has many teeth, making the angle between two adjoining teeth smaller. Sometimes the teeth have to be shortened down to almost the pitch diameter. The immediate consequence of this is an appreciably increased backlash, which is therefore inherent in this design. The backlash situation is somewhat worsened by the need for some safety factor to avoid any possible jamming, which would occur if the leading corner of tooth D were to strike against the top of tooth M. This danger exists especially if the mechanism is subjected to environmental changes in temperature, which cause dimensional variations.

It is often not feasible to make driver or pinion of one piece of metal. More often than not each of them must be assembled of two pieces, which calls for the additional expense of making the two compound pieces concentric and of lining them up prop-

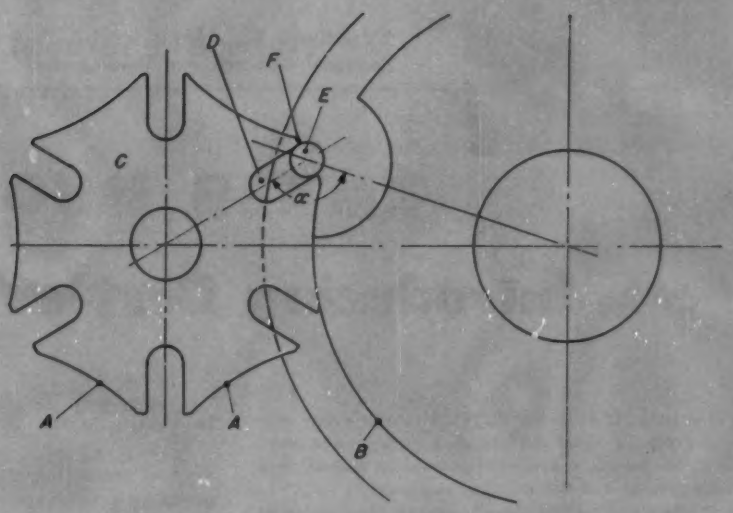


Fig. 5—Conventional geneva drive.

erly. Fig. 2 shows an actual mechanism of this type. In this example only one tooth has been left intact.

Modified Geneva Drive: The enumerated disadvantages are obviated in the "modified geneva drive," Figs. 3 and 4. Two features distinguish the modified geneva from the conventional geneva, Fig. 5.

It should be pointed out that in both the conventional and the modified geneva, as shown in the schematic figures, the engagement angle α is for some specific design considerations not always 90 deg, as would be desirable from a theoretical point of view, but larger than 90 deg. An engagement angle of 90 deg is mandatory if high torque loads have to be transmitted, because the "jerk"—third derivative of the angular displacement—is a minimum in this case. However, in some applications connected with instrumentation with negligible torque loads, it is desirable to have the "transfer" accomplished in as short a time as possible, and it was found by experience that engagement angles up to about 130 deg can be tolerated with no resulting audible click even at 1000 rpm.

A conventional geneva whose design is based on the foregoing conditions, employing an engagement angle of 130 deg, would schematically look like Fig. 5. As can be seen clearly, the locking arc *A* is very shallow, allowing in the locking position some measurable angular displacement due to the necessary clearance between itself and the locking disk *B*. This has two undesirable consequences. First, the instrument member attached to or driven by the star *C* assumes an angular position lying anywhere between two limits which are determined by the play between the locking disk and the locking arc. The fact that the locking arc is very shallow makes this play quite appreciable. Second, any slight angular displacement of the star brings the slot *D* out of its correct position to receive the driving pin *E*. Such a displacement could cause the pin to strike the land *F* and thus jam the mechanism. Clearly, a conventional geneva could not solve the problems imposed by the necessity to improve on the mutilated-tooth intermittent drive.

Advantages: The modified geneva possesses, as mentioned before, two features which distinguish it from the conventional geneva:

1. The locking arcs and the drive slots of the star lie in two different levels, Fig. 3. This makes possible employment of longer, less shallow locking arcs which contact the locking disk in wider angles and thus insure a much better locking action, resulting in greatly reduced backlash.

2. The slots do not terminate at the active point of engagement, but are extended beyond it in a funnel *G* of circular shape, Fig. 3. This funnel is dimensioned in such a way as to function as an effective cam. If, due to machining inaccuracies or too generous clearances, the star should shift angularly in its locked position and thus displace the slot from its proper position to receive the driving pin, the pin will make contact with one of the two faces of *G* and cam the star into its exact angular location whereupon the pin can enter freely into the slot.

An additional advantage is the fact that the driver and the driven member are each one piece, thus saving machining and assembly time.

Mechanisms of this kind have been successfully made and tested at Ford Instrument Co., to whom the author is indebted for permission to publish these findings.

The Personal Side of Engineering

By Edwin C. Nevis
Personnel Research and Development Corp., Cleveland

Introducing Dr. Nevis

In this issue, MACHINE DESIGN starts a new feature—a group of short articles on engineers and engineering, on personal and professional problems, and on management and the working engineer.

As the headline on this page indicates, these columns will emphasize the relationships between the individual engineer and his environment—his job, his supervisors, his company management, and his profession. The author, a practicing psychologist, is well qualified to discuss these factors.

Edwin C. Nevis is a graduate of City College of New York, Columbia University and Western Reserve University, where he received his Ph.D. Dr. Nevis began his college career as an engineering student but shifted to psychology before receiving his first degree. His experience includes almost ten years of intensive work in the psychological assessment of personnel for selection, placement, and development purposes. He has conducted research studies for both industrial and military organizations. He served for two years as director of research for a midwestern consulting firm and is now vice president of Personnel Research and Development Corp., Cleveland. He is also a lecturer in psychology at Western Reserve University.

IT IS quite apparent to all concerned with the management of American industry that a problem of great magnitude exists today with regard to the effective utilization of our engineers.

We hear a great deal concerning the shortage of engineering personnel. We hear that manpower requirements are far in excess of the number of professionally trained people in this field and that schools are unable to turn out sufficient numbers of new engineers to meet present and future demands. All of us are also familiar with the fact that engineering talent is not always utilized to the best advantage of the engineer or his company. Furthermore, we see many engineers moving out of engineering into general administration or other avenues, such as sales.

Adding to the demand for engineers as such is a tremendous need for engineering-trained people who are capable of managing groups of technical specialists. We are told that there are problems in connection with the training and development of persons who not only are technically skilled but who also possess the skills of leadership necessary to obtain results through the efforts of others.

Accompanying these problems, there seems to be a great transition underway in the status of engineers as a professional group. Engineers are becoming more and more conscious of the way they are treated by their company and by society as a whole. Once a group of rather high status, then having lost some ground, the engineering profession as a whole is making a determined effort to regain its standing in the eyes of others. This includes the way they are treated by their superiors as well as such other manifestations as salary level and community acceptance.

No matter from what angle the situation is viewed—whether from the standpoint of the management group which must lead engineers or from the standpoint of the engineer trying to develop a successful career for himself—one thing seems certain: there is a crying need for increased understanding of the human relations involved.

There is a need to know more about the kinds of satisfactions and frustrations associated with the engineering career. We need to know more about the kinds of people who want to become engineers as well as the reasons for success or failure in this occupation. Engineers have a need to know more about the ways in which they can make a maximum contribution, and what they can do to improve their performance and advance their status. Engineering supervisors can benefit greatly from greater understanding of what to expect from an engineer, how to deal with engineers, and how to motivate them.

These columns will attempt to provide some factual information and insights based upon experience in the selection, development and counseling of engineers. All of the articles will be designed to pass on some food for thought in those areas and problems with which engineers are so greatly concerned today. There will be no panaceas presented in these discussions, nor will short-cut formulas be given. Rather, an attempt will be made to stimulate thinking by presenting information and concepts concerning some of the basic problems of self-understanding and improved human relations necessary for successful job performance and career advancement in engineering.

MACHINE DESIGN
Data Sheet

A simplified tabular procedure for design analysis of

NONUNIFORM BEAMS

with fixed ends

By R. A. Di Taranto
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Camden, N. J.

DESIGN of machine members often requires analysis of a beam with fixed ends. Purpose of such analyses, usually, is to determine dependability of the member from either a stress or a deflection standpoint. In addition, it may be necessary to evaluate shear or moment reactions at either or both fixed ends to find how loads will be transferred to adjacent structures.

This article presents a simple systematic procedure for determining end reactions, deflections, slopes, shears and moments of a statically loaded nonuniform beam with fixed ends ("fixed-fixed"). It is based on a tabular method of calculation which involves, at most, cumulative multiplication operations.

Calculation Procedure: Basic steps of the method can be best outlined in reference to the solution in Example 1. Sign convention and symbols are defined in Fig. 1 and Nomenclature. A fixed-fixed nonuniform beam with concentrated load, or loads, F is assumed.

1. Determine actual stiffness (EI) distribution along the beam and plot in form of EI diagram as shown, (b) in Example 1.

2. Divide the beam into stations, with a station located at each end support, at each point of load application, and at any other point where the shear, moment, deflection and/or slope are required. Stations are numbered consecutively from right to left, with the left support designated station b.

3. Replace the actual member with an equivalent beam in which stiffness EI across each section is uniform, Example 1, (c). The EI value for each section of the equivalent beam is the arithmetic average of the actual EI values across that section.

4. Tabulate general data for each beam section,

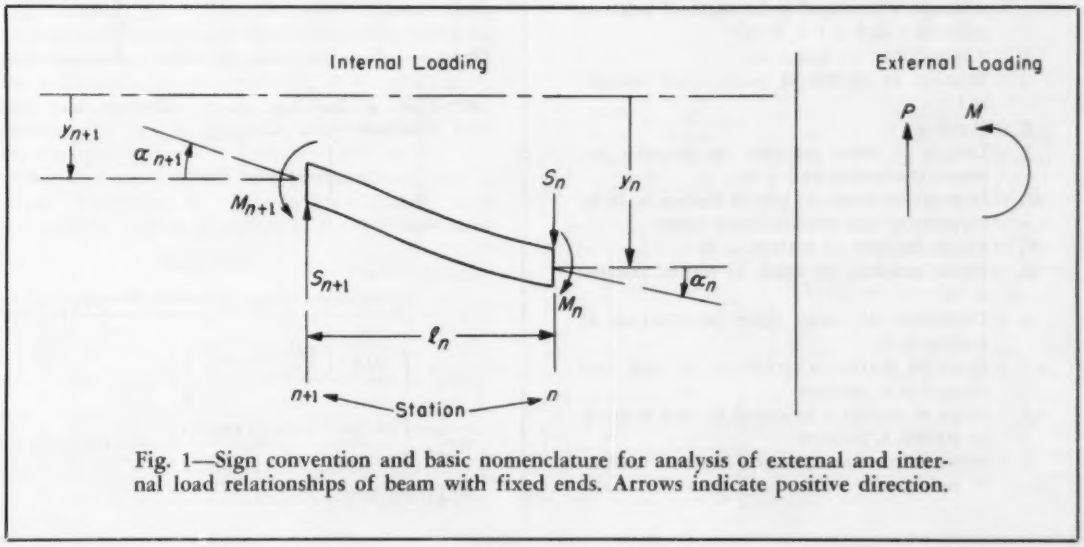


Fig. 1—Sign convention and basic nomenclature for analysis of external and internal load relationships of beam with fixed ends. Arrows indicate positive direction.

including values for: length, l_n; average stiffness, $(EI)_n$; deflection coefficients, d_{Fn} and d_{Mn}; and slope coefficients, v_{Fn} and v_{Mn}. In this method of analysis, deflection and slope coefficients are determined by considering the section of beam between stations n and $n + 1$ cantilevered at station $n + 1$. Values are calculated in terms of the average EI value and the length of the beam section between stations, as though each station were connected by uniform stiffness cantilever beams. Thus, the deflection and slope coefficients, based on conventional cantilever beam relationships, are:

$$d_{Fn} = \frac{l_n^3}{3(EI)_n} \quad (1)$$

$$d_{Mn} = v_{Fn} = \frac{l_n^2}{2(EI)_n} \quad (2)$$

$$v_{Mn} = \frac{l_n}{(EI)_n} \quad (3)$$

5. Complete tables of calculated coefficient values, g, f, G and C, Example 1, (e). Development of these data is treated briefly in the following discussion, which summarizes details of the calculation procedures covered in References 1 and 2.

BASIC RELATIONSHIPS: For a typical beam section, Fig. 1, the relationship between deflection and slope at station $n+1$ in terms of these quantities at station n may be readily obtained. The deflection at station $n+1$ is the superposition of (1) the deflection at station n, (2) the change in deflection from station n to $n+1$ due to the rotation of this section considered rigid and (3) the elastic deflection of this section (assumed cantilevered at station $n+1$) loaded at station n by moment M_n and shear S_n.

The slope at station $n+1$ is the superposition of (1) the slope at station n and (2) the change in slope between station n and $n+1$ caused by the elastic rotation due to shear S_n and moment M_n acting on station n with the section considered cantilevered at station $n+1$. The shear at station n is the sum of all reactions and loads at and to the right of this station.

The moment, M_n, at station n is the sum of all

Nomenclature

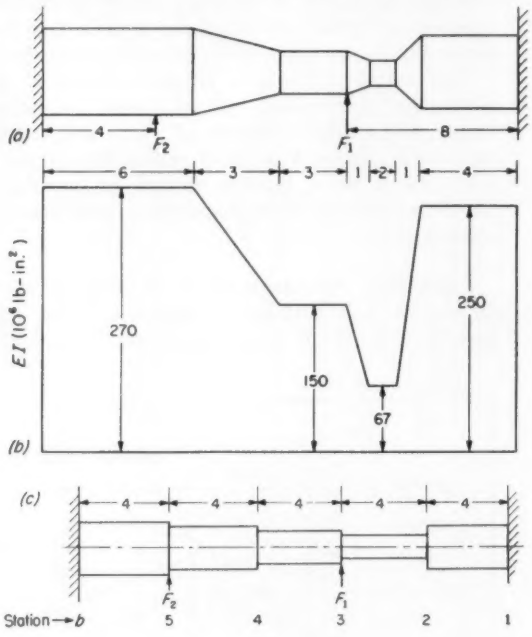
d_{Fn} = Deflection at station n produced by unit load at station n, in.
d_{Mn} = Deflection at station n produced by unit moment at station n, in.
E = Young's modulus of elasticity, psi
EI = Stiffness of beam cross section, lb-in.^{2}
$(EI)_n$ = Average stiffness of beam segment between stations n and $n + 1$, lb-in.^{2}
F = Applied load on beam, lb
I = Moment of inertia of beam cross section, in.^{4}
K = Constant
l_n = Length of beam segment, or distance, between stations n and $n + 1$, in.
M_n = Moment on beam to left of station n, lb-in.
n = Number of any station along beam
P_n = Shear reaction at station n, lb
S_n = Shear reaction on beam to left of station, n, lb
y_n = Deflection of beam from equilibrium at station n, in.
v_{Fn} = Slope at station n produced by unit load at station n, radians
v_{Mn} = Slope at station n produced by unit moment at station n, radians
α_n = Slope of elastic curve of beam at station n, radians

Example 1—

A representative fixed-fixed nonuniform beam with two concentrated static loads, F_1 and F_2, is shown at (a). Problem is to find the end reactions as well as the deflections, slopes, shears and moments along the beam member.

An EI diagram, Step 1, for this beam is plotted at (b). This plot is based on calculated values of EI along the beam member.

Division of the beam into stations, Step 2, and development of an equivalent beam with sections of uniform stiffness, Step 3, are demonstrated at



$(EI)_1 = 250\ (10^6)$

$(EI)_2 = \left[\frac{\left(\frac{250-67}{2} + 67\right) + 67(2) + \left(\frac{150-67}{2} + 67\right)}{4}\right] 10^6 = 101\ (10^6)$

$(EI)_3 = \left\{\frac{150(3) + \left[\frac{270-150}{3(2)} + 150\right]}{4}\right\} 10^6 = 154\ (10^6)$

$(EI)_4 = \left[\frac{\left(\frac{270-190}{2} + 190\right)2 + 270(2)}{4}\right] 10^6 = 250\ (10^6)$

$(EI)_5 = 270\ (10^6)$

moment contributions of reactions and loads to the right of station n plus all concentrated moments at and to right of this station.

If a linear relationship of the foregoing quantities is assumed, it can be shown that

$$y_n = g_{M1n} M_1 + g_{P1n} P_1 + g_{F1n} F_1 \quad (4)$$

$$\alpha_n = f_{M1n} M_1 + f_{P1n} P_1 + f_{F1n} F_1 \quad (5)$$

$$S_n = G_{M1n} M_1 + G_{P1n} P_1 + G_{F1n} F_1 \quad (6)$$

$$M_n = C_{M1n} M_1 + C_{P1n} P_1 + C_{F1n} F_1 \quad (7)$$

where g, f, G and C can be generally defined as coefficients of deflection, slope, shear and moment. For example, g_{M1n} is the coefficient which, when multiplied by moment M_1, gives the contribution of M_1 to the deflection at station n. Likewise, coefficients g_{P1n} and g_{F1n} represent the contribution of shear P_1 and applied load F_1 to the deflection at station n. Similar relationships hold for the f, G and C coefficients which represent the contributions to slope, shear and moment, respectively, at station n.

EVALUATION OF COEFFICIENTS: Values of the different coefficients are given by a set of recurrence equations developed from analysis of basic beam

Nonuniform Beam Analysis

(c). For convenience, six equidistant stations have been employed. Note that a station is assigned at each point of load application and at each support. Shapes of sections in the equivalent beam correspond to calculated average EI values.

From Equations 1, 2 and 3, using the average EI values, deflection and slope coefficients can be determined and tabulated, Step 4, (d). Remaining tables for solution of coefficients of recurrence equations may now be completed, Step 5, (e). An M_1 table and a P_1 table are completed for stations 1 to b. An F_1 table is completed for stations 3 to b and an F_2 table for stations 5 to b. Initial conditions for the F_2 table correspond to those of the F_1 table. Thus, at station 5: $g_{F2} = 0$, $f_{F2} = 0$, $G_{F2} = -1$, $C_{F2} = 0$. In these tables, the initial conditions are filled in and the remaining values computed station by station. Progression of calculations is indicated by the "equations" at the top of each table column. In these equations, numbers identify table columns; values from the same station or row are circled, values from the preceding station or row are enclosed by a square.

Moment M_1 and shear P_1 can now be found from Equations 13 and 14, Step 6. From the foregoing tables, the following values will be needed for computations: $g_{M1b} = -1.23337$, $f_{M1b} = 0.11279$, $g_{p1b} = -8.2604$, $f_{P1b} = 1.02241$, $g_{F1b} = -1.31607$, $f_{F1b} = 0.29610$, $g_{F2b} = -0.03951$, $f_{F2b} = 0.02963$. Each applied force is evaluated separately to find the beam end reactions. From Equation 15, $\Delta = -0.32933$. From Equation 13, in terms of F_1, $P_1 = -0.65820\ F_1$ and from Equation 14, $M_1 = 3.3415\ F_1$. A similar solution for load F_2 gives: $P_1 = -0.0974\ F_2$ and $M_1 = 0.6205\ F_2$.

Beam calculations can now be completed, Step 7. From Equation 6, $P_b = S_b = -0.3418\ F_1$ and $-0.9026\ F_2$. From Equation 7, $M_b = -2.1776\ F_1$

(d) General Data

n	ℓ_n (in.)	$(EI)_n$ (10^6 lb-in.^{2})	d_{Fn} (10^{-6} in.)	d_{Mn} (10^{-6} in.)	v_{Fn} (10^{-6} rad)	v_{Mn} (10^{-6} rad)
1	4	250	0.08533	0.032	0.032	0.016
2	4	100	0.2133	0.080	0.080	0.04
3	4	154	0.13853	0.05195	0.06195	0.02597
4	4	250	0.08533	0.032	0.032	0.016
5	4	270	0.07901	0.2963	0.2963	0.01482

(e) M_1 Table

n	1: G_{M1n} = [1]	2: C_{M1n} = [2]+[2]×[1]	3: $f_{M1(n+1)}(10^6)$ = [3] − [v_F]×①− (4)×②	4: $\Delta g_{M1(n+1)}(10^6)$ = [2]×③+[d_F]×①+(4)×④	5: $g_{M1n}(10^6)$ = [5]−[4]
			0		
1	0	-1.00000	0.01600	0.03200	0
2	0	-1.00000	0.05600	0.14400	-0.03200
3	0	-1.00000	0.08197	0.27595	-0.17600
4	0	-1.00000	0.09797	0.35990	-0.45195
5	0	-1.00000	0.11279	0.42153	-0.81184
6	0	-1.00000	——	——	-1.23337

P_1 Table

n	1: G_{P1n} = [1]	2: C_{P1n} = [2]+[2]×[1]	3: $f_{P1(n+1)}(10^6)$ = [3]−(4)×①−(4)×②	4: $\Delta g_{P1(n+1)}(10^6)$ = [2]×③+(4)×①+(4)×②	5: $g_{P1n}(10^6)$ = [5]−[4]
			0		
1	-1.00000	0	0.03200	0.04267	0
2	-1.00000	-4.00000	0.27200	0.55470	-0.04267
3	-1.00000	-8.00000	0.53174	1.57285	-0.59737
4	-1.00000	-12.00000	0.75574	2.55363	-2.17022
5	-1.00000	-16.00000	1.02241	3.53655	-4.72385
6	-1.00000	-20.00000	——	——	-7.26040

F_1 Table

n	1: G_{F1n} = [1]	2: C_{F1n} = [2]+[2]×[1]	3: $f_{F1(n+1)}(10^6)$ = [3]−[v_F]×①−(4)×②	4: $\Delta g_{F1(n+1)}(10^6)$ = [2]×③+[d_F]×①+(4)×②	5: $g_{F1n}(10^6)$ = [5]−[4]
			0		
1	0	0	0	0	0
2	0	0	0	0	0
3	-1.00000	0	0.05195	0.06926	0
4	-1.00000	-4.00000	0.14795	0.37896	-0.06926
5	-1.00000	-8.00000	0.29610	0.86839	-0.44773
6	-1.00000	-12.00000	——	——	-1.31607

F_2 Table

n	1: G_{F2n} = [1]	2: C_{F2n} = [2]+[2]×[1]	3: $f_{F2(n+1)}(10^6)$ = [3]−[v_F]×①−(4)×②	4: $\Delta g_{F2(n+1)}(10^6)$ = [2]×③+[d_F]×①+(4)×②	5: $g_{F2n}(10^6)$ = [5]−[4]
			0		
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	-1.00000	0	0.02963	0.03951	0
6	-1.00000	-4.00000	——	——	-0.03951

relationships.[1] Solution of these equations is the function of the simplified tabular method presented here. One P_1 (shear) table and one M_1 (moment) table are completed from station 1 to b. An F (applied load) table, with values corresponding to those of the P_1 table, is completed for each applied force on the beam from the station of force application to station b.

Procedure for completing each table is the same. Values for each station are entered in the columns in order from left to right. For example, the columns of the P_1 table represent solutions of:

[1]References are tabulated at end of article.

Example 1—(Continued)

and $-2.6717\,F_2$. External load relationships for the beam are depicted at (f) in separate sketches for F_1 and F_2. Both cases satisfy equilibrium conditions. Combined effect of both forces can be found by algebraic summation.

Deflection, slope, shear and moment values at each station can be determined from Equations 4 to 7 for each applied force. These calculations are tabulated at (g). Sample calculations for station 2, in terms of F_1, are:

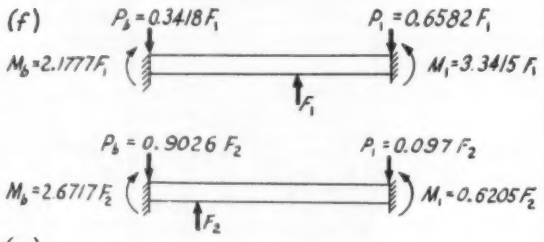
$$\frac{y_2}{F_1} = -0.032(3.3415) - 0.04267(-0.6582) + 0 = -0.07884$$

$$\frac{\alpha_2}{F_1} = 0.016(3.3415) + 0.032(-0.6582) + 0 = 0.0351$$

$$\frac{M_2}{F_1} = -(3.3415) - 4(-0.6582) + 0 = -0.7087$$

$$\frac{S_2}{F_1} = 0 - 1(-0.6582) + 0 = 0.65820$$

(f)



(g)

n	$\frac{y}{F_1}(10^6)$	$\frac{\alpha}{F_1}(10^6)$	$\frac{M}{F_1}$	$\frac{S}{F_1}$
1	0	0	-3.3415	0.6582
2	-0.0788	0.0351	-0.7087	0.6582
3	-0.11492	0.0081	1.9241	0.3411
4	-0.15085	-0.0241	0.5568	0.3411
5	-0.05114	-0.0221	-0.8103	0.3411
6	0	0	-2.1776	0.3411

n	$\frac{y}{F_2}(10^6)$	$\frac{\alpha}{F_2}(10^6)$	$\frac{M}{F_2}$	$\frac{S}{F_2}$
1	0	0	-0.6205	0.0974
2	-0.01570	0.00681	-0.2308	0.0974
3	-0.05101	0.00825	0.1590	0.0974
4	-0.06896	-0.00095	0.5487	0.0974
5	-0.04346	-0.01284	0.9385	-0.9026
6	0	0	-2.6717	-0.9026

$$G_{P1n} = G_{P1(n-1)} \quad (8)$$

$$C_{P1n} = C_{P1(n-1)} + l_{n-1}\,G_{P1(n-1)} \quad (9)$$

$$f_{P1(n+1)} = f_{P1n} - v_{Fn}\,G_{P1n} - v_{Mn}\,C_{P1n} \quad (10)$$

$$\Delta g_{P1(n+1)} = f_{P1(n+1)}\,l_n + d_{Fn}\,G_{P1n} + d_{Mn}\,C_{P1n} \quad (11)$$

$$g_{P1n} = g_{P1(n-1)} - \Delta g_{P1n} \quad (12)$$

Similar solutions are provided by the other tables.

First step in the development of the tables is the evaluation of initial conditions. For the P_1 table, at $n = 1$, these conditions are: $g_{P1} = 0$, $f_{P1} = 0$, $G_{P1} = -1$, $C_{P1} = 0$. For the M_1 table, at $n = 1$: $g_{M1} = 0$, $f_{M1} = 0$, $G_{M1} = 0$, $C_{M1} = -1$. For the F tables, at the station at point of force application: $g_F = 0$, $f_F = 0$, $G_F = -1$, $C_F = 0$. From these data, the tables are easily completed by cumulative multiplication and addition operations as shown in Example 1, (e).

6. Compute values of moment M_1 and shear P_1. For this calculation, values of the f and g coefficients at station b are tabulated from the M_1, P_1 and F tables. Solution is then given by:

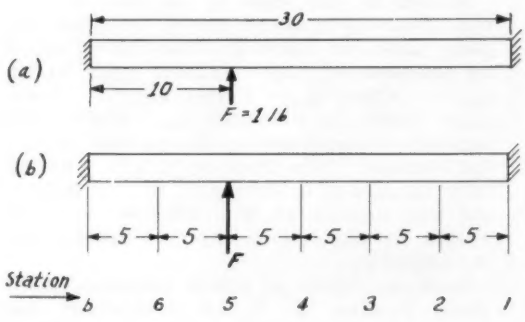
$$P_1 = \left(\frac{g_{Fb}\,f_{M1b} - g_{M1b}\,f_{Fb}}{\Delta}\right) F \quad (13)$$

$$M_1 = \left(\frac{g_{P1b}\,f_{Fb} - g_{Fb}\,f_{P1b}}{\Delta}\right) F \quad (14)$$

where

Example 2—
Accuracy of Calculations

A comparison of results obtained by the tabular method with those of the exact analytic solution is provided by analysis of the fixed-fixed uniform beam sketched at (a). For this beam, $EI =$



(c) General Data

n	ℓ_n (in.)	$(EI)_n$ (10^6 lb-in^2)	d_{Fn} (10^{-6} in.)	d_{Mn} (10^{-6} in.)	v_{Fn} (10^{-6} rad)	v_{Mn} (10^{-6} rad)
1	5	20	2.08	0.625	0.625	0.250
2	5	20	2.08	0.625	0.625	0.250
3	5	20	2.08	0.625	0.625	0.250
4	5	20	2.08	0.625	0.625	0.250
5	5	20	2.08	0.625	0.625	0.250
6	5	20	2.08	0.625	0.625	0.250

$$\Delta = g_{M1b} f_{P1b} - g_{P1b} f_{M1b} \qquad (15)$$

Derivation of these equations is based on the boundary conditions, $y_b = 0$ and $\alpha_b = 0$. In the use of Equations 13 and 14, each applied force (F_1, F_2, etc.) is taken separately to find reactions M_1 and P_1 in terms of that force.

7. Complete beam calculations. Deflection, slope, shear and moment at any station can now be determined for each applied force from Equations 4, 5, 6 and 7, using values of M_1 and P_1 calculated from Equations 13 and 14. The final solution with two or more forces active on the beam is obtained by algebraic summation of the separate deflections, slopes, shears or moments at each station.

As a check on accuracy of beam calculations, external force and moment relationships determined for each applied force should satisfy equilibrium conditions: $\Sigma M = 0$, $\Sigma F = 0$, $\alpha_b = 0$, and $y_b = 0$.

Design Practice: Application of the method in a typical nonuniform beam analysis is illustrated in Example 1. In Example 2, the method is applied to a uniform beam and results compared with an exact analytical solution.

As in most beam problems where deflections due to bending alone are considered, the method outlined here is best suited for members with large length-width ratios.

External moments along the beam can be accounted for by a similar procedure. A separate m table is calculated from point of application to station b and the following expressions are used instead of the ones previously discussed:

$$M_1 = \frac{g_{P1b} f_{mb} - g_{mb} f_{P1b}}{\Delta} \qquad (16)$$

$$P_1 = \frac{g_{mb} f_{M1b} - g_{M1b} f_{mb}}{\Delta} \qquad (17)$$

$$y_n = g_{M1n} M_1 + g_{P1n} P_1 + g_{mn} m \qquad (18)$$

$$\alpha_n = f_{M1n} M_1 + f_{P1n} P_1 + f_{mn} m \qquad (19)$$

$$S_n = G_{M1n} M_1 + G_{P1n} P_1 + G_{mn} m \qquad (20)$$

$$M_n = C_{M1n} M_1 + C_{P1n} P_1 + C_{mn} m \qquad (21)$$

where m is the applied moment and Δ is given by Equation 15.

REFERENCES

1. N. O. Myklestad—"A Simple Tabular Method of Calculating Deflections and Influence Coefficients of Beams," *Journal of the Aeronautical Sciences*, Vol. 12, 1945, Page 23.
2. R. A. DiTaranto—"A Method for Determining the Flexural Effects of Statically Loaded Beams on Multiple Elastic Supports," ASME Paper No. 56—APM-24, presented at the National Applied Mechanics Conference of the ASME, Urbana, Ill., June 14-16, 1956.

(d)

P_1 Table

n	1 G_{P1n} = [1]	2 C_{P1n} = [2]+[ℓ]×[1]	3 $f_{P1(n+1)}(10^6)$ = [3]−(½)×[1]−(½)×[2]	4 $\Delta g_{P1(n+1)}(10^6)$ = [ℓ]×[3]+[ℓ²/12]×([1]+[2])	5 $g_{P1n}(10^6)$ = [5]−[4]
			0		
1	-1.00000	0	0.625	1.045	0
2	-1.00000	-5	2.500	7.295	-1.045
3	-1.00000	-10	5.625	19.795	-8.34
4	-1.00000	-15	10.000	38.54	-28.135
5	-1.00000	-20	15.625	63.545	-66.675
6	-1.00000	-25	22.500	94.82	-130.22
b	-1.00000	-30	——	——	-225.04

F Table

n	1 G_{Fn} = [1]	2 C_{Fn} = [2]+[ℓ]×[1]	3 $f_{F(n+1)}(10^6)$ = [3]−(½)×[1]−(½)×[2]	4 $\Delta g_{F(n+1)}(10^6)$ = [ℓ]×[3]+[ℓ²/12]×([1]+[2])	5 $g_{Fn}(10^6)$ = [5]−[4]
			0		
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	-1.00000	0	0.625	1.0450	0
6	-1.00000	-5	2.5000	7.2950	-1.0450
b	-1.00000	-10	——	——	-8.340

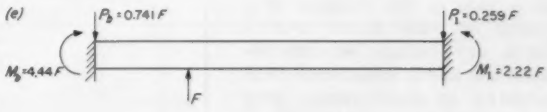
M_1 Table

n	1 G_{M1n} = [1]	2 C_{M1n} = [2]+[ℓ]×[1]	3 $f_{M1(n+1)}(10^6)$ = [3]−(½)×[1]−(½)×[2]	4 $\Delta g_{M1(n+1)}(10^6)$ = [ℓ]×[3]+[ℓ²/12]×([1]+[2])	5 $g_{M1n}(10^6)$ = [5]−[4]
			0		
1	0	-1.00000	0.25	0.625	0
2	0	-1.00000	0.50	1.875	-0.625
3	0	-1.00000	0.75	3.125	-2.500
4	0	-1.00000	1.00	4.375	-5.625
5	0	-1.00000	1.25	5.625	-10.000
6	0	-1.00000	1.50	6.875	-15.625
b	0	-1.00000	——	——	-22.500

$20(10^6)$ lb-in.^{2} For convenience, the beam will be divided into six sections of equal length, l_n = 5 in., (*b*).

For the tabular method, general data are compiled at (*c*); M_1, P_1 and F tables appear at (*d*). From Equation 15, $\Delta = -168.69$ and from Equations 13 and 14, $P_1 = -0.259\ F$ and $M_1 = 2.22\ F$. From Equations 6 and 7, $P_b = -0.741\ F$ and $M_b = -4.44\ F$. These external load relationships satisfy equilibrium conditions, (*e*). Calculated deflection, slope, shear and moment values (Equations 4 to 7) for each station are tabulated at (*f*) along with comparable results obtained from the analytic solution.

(e)



(f)

n	$\frac{y_n}{F}(10^6)$ Tabular Method	$\frac{y_n}{F}(10^6)$ Analytic Solution	$\frac{\alpha_n}{F}(10^6)$ Tabular Method	$\frac{\alpha_n}{F}(10^6)$ Analytic Solution	$\frac{M}{F}$ Tabular Method	$\frac{M}{F}$ Analytic Solution	$\frac{S}{F}$ Tabular Method	$\frac{S}{F}$ Analytic Solution
1	0	0	0	0	-2.22	-2.22	0.259	0.259
2	-1.12	-1.12	0.393	0.393	-0.925	-0.925	0.259	0.259
3	-3.39	-3.4	0.462	0.462	0.37	0.37	0.259	0.259
4	-5.21	-5.21	0.13	0.13	1.66	1.66	0.259	0.259
5	-4.94	-4.94	-0.37	-0.37	2.97	2.97	0.741	0.741
6	-2.01	-2.006	-0.635	-0.635	-0.735	-0.735	0.741	0.741
b	0	0	0	0	-4.44	-4.44	0.741	0.741

Basic principles and characteristics of

Valve-Controlled Hydraulic Servomechanisms

HYDRAULIC servomechanisms in the sense of this discussion are closed-loop control systems which amplify low-power or force-level signals into high-power or force-level output quantities. A servomechanism consists of four basic components:

1. An input-signal transducer which transforms the desired input quantity into a convenient physical form for the actuation of the fluid-power control valve. This mechanism may be in the form of a mechanical linkage, an electromechanical transducer or a pressure transducer.
2. The fluid-power control valve, a power dissipative control device which meters the correct amount of fluid power to the fluid motor. The full power available from the power source is never available at the load. Appreciable pressure drops are associated with even the wide open orifices of the valve.
3. The fluid motor which transforms the controlled fluid power into mechanical power either in the form of the linear motion of a ram or the rotation of a piston or vane motor. For a force or position servomechanism the motor transforms fluid pressure or fluid volume into the desired output quantities.
4. The feedback element which transforms the output quantity, in the form of a position, velocity, force or pressure, into a physical form such that the output quantity can be compared with the desired value of the input quantity. The feedback element may be a mechanical linkage, or a pressure, position, velocity or force transducer.

Another form of hydraulic servomechanism of equal importance to the valve-controlled system utilizes a variable-displacement hydraulic pump which usually runs at constant speed and delivers controlled quantities of fluid power to either a fixed or variable-displacement fluid motor. Such systems are best known as positive-displacement hydraulic transmissions. The displacement of the hydraulic pump is commonly controlled by a valve-controlled servomechanism so that in effect the pump-controlled type of system can be considered a subsequent stage to the valve-controlled system.

Generally speaking, valve-controlled servomechanisms are far less efficient in the control of power than the pump-controlled transmission since a considerable portion of the generated power is dissipated in the control-valve orifices. The attraction of the valve-controlled system rests in the possibility of very rapid response and low cost relative to the pump-controlled system. For these reasons, the control of large fluid power

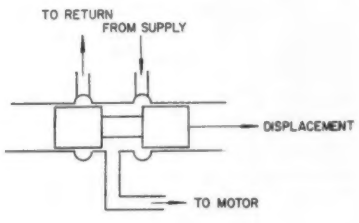


Fig. 1—Closed-center three-way spool valve.

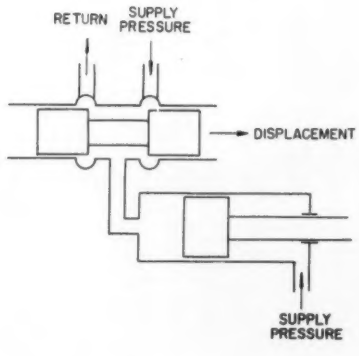


Fig. 2—Open-center three-way spool valve.

By Gerhardt Reethof and Leroy Taylor

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(in excess of about 20 hp) is accomplished primarily by the pump-controlled systems.

A brief review of valve-controlled servomechanisms will establish a clear terminology.

Closed-Center Three-Way Valve: This type of control valve is either of the spool or poppet type. A three-way spool valve, Fig. 1, opens the motor port to either supply source or return line. In the midposition, the ideal three-way valve just seals the motor port from either supply source or return system. In certain instances, the valve-sleeve combination is designed so that a certain axial motion of the spool is required to move from just-open-to-supply to just-open-to-return. This motion is termed the overlap of the valve. If on the other hand, both supply and return can communicate with the motor simultaneously within a certain displacement of the valve, this displacement is termed the underlap of the valve.

Open-Center Three-Way Valve: In certain applications, the restrictions between supply source and motor as well as the return line and motor, remain open to varying extents throughout the operation of the valve. This type of valve is shown in Figs. 2 and 3, depicting the spool and flapper versions respectively. If either of the orifices in the spool type valve is closed, Fig. 2, the valve will operate as a closed-center valve in a wide-open condition.

Closed-Center Four-Way Valve: Two closed-center three-way valves as shown in Fig. 1 can be combined into a four-way valve, Fig. 4. The analysis of all four-way valves can therefore be based on the far simpler behavior of three-way valves.

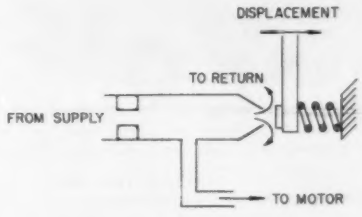
Open-Center Four-Way Valve: The open-center three-way valves can similarly be combined into four-way valves, Figs. 5 and 6. Two different porting arrangements are shown in Figs. 4 and 5 for the spool type four-way valves. Both arrangements can be adapted to either open-center or closed-center operation. The somewhat more complex scheme of Fig. 4 is usually preferred for two reasons:

1. Better radial support of the valve spool prevents hanging up of the spool at the control edges.
2. The valve will be more stable hydrodynamically.

Valve Configurations: Basically, flow valves can be divided into two broad classes: sliding and seating.

The sliding type valve is one whose controlling member moves in a direction perpendicular to the direction of the pressure forces

Fig. 3—Open-center three-way flapper valve with fixed upstream orifice.



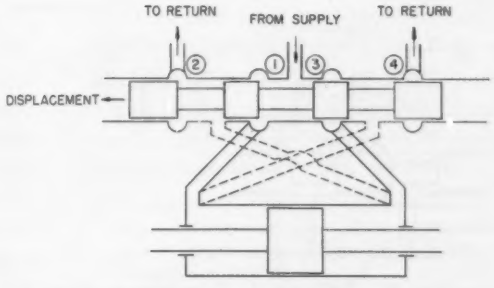


Fig. 4—Closed-center four-way valve.

which act on the controlling member. On the other hand, the controlling member of the seating type valve moves in the same direction as the direction of the pressure force. Following these two definitions, spool, sliding and rotary plate valves are of the sliding type, and poppet, ball and flapper valves are of the seating type.

Single spool valves are illustrated in Figs. 1, 2, 4 and 5. The first two are three-way valves; the last two are four-way valves. The spool type valves have been the most commonly used valve configuration in servo valve work. This is particularly true for the second and third stage of multistage servo valves. The first stage of electrohydraulic servo valves is commonly actuated by relatively low-force-level electromagnetic actuators. These low available force levels require very close tolerances in manufacture and extreme cleanliness in operation to ensure reliable components.

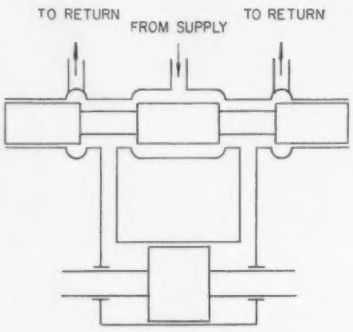


Fig. 5—Open-center four-way valve.

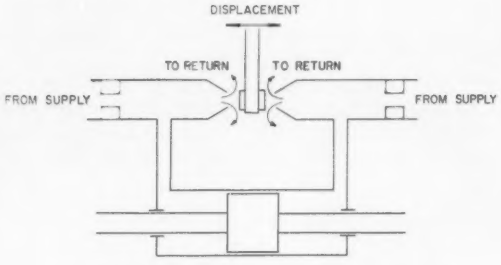


Fig. 6—Open-center four-way valve with fixed upstream orifice.

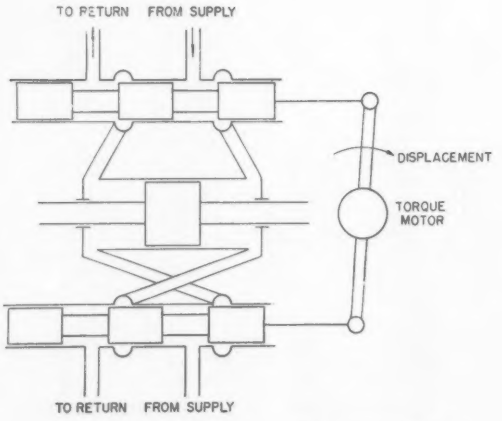


Fig. 7 — Split-spool, closed-center four-way valve.

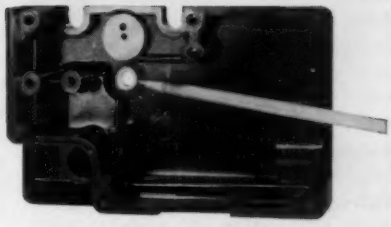
The tolerance problem can be somewhat reduced by recourse to the split-spool valve, either two two-way valves for a three-way combination or two three-way valves for the four-way combination. Fig. 7 shows one possible construction. The split-spool valve with a walking beam is also insensitive to linear accelerations such as might be encountered in ground mobile and airborne equipment.

The flapper valve, Figs. 3 and 6, has become a very successful pilot (first) stage for multistage hydraulic valves. Inherent simplicity of construction makes this design an inexpensive and rugged valve. Because of the large actuating forces required of this seating type valve (large relative to an equivalent spool type valve), the fluid power which can be controlled with conventional electronically operated electromagnetic actuators is quite small.

Sliding flat-plate and rotary flat valves of the sandwich type have been introduced within recent years. These valves were developed by Dr. S. Y. Lee of Massachusetts Institute of Technology to reduce some of the manufacturing difficulties inherent in spool-type four-way valves. The "plug and hole" construction illustrated in Fig. 8 lends itself best to closed-center operations.

Another innovation of Dr. Lee's is the suspension valve. This is a valve of the sliding type using the "plug and hole" construction principle. This conception lends itself best to small pilot-valve designs, Fig. 9.

The jet-pipe valve, because of its wide and successful use in the process-control field, should be mentioned. The jet-pipe control



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Circle 486 on page 19

works on a quite different principle than the metering-orifice type valves which have so far been discussed. As shown in Fig. 10, the jet-pipe control mechanism moves the high-velocity jet of fluid toward one or the other openings leading to either side of a ram actuator. Kinetic head of the jet is converted into a static head or pressure which acts on one side or the other of the ram. Simplicity of construction and the absence of closely fitted surfaces results in a reliable and inexpensive valve. Low speed of response relative to spool type valves appears to limit the use of this otherwise promising valve configuration.

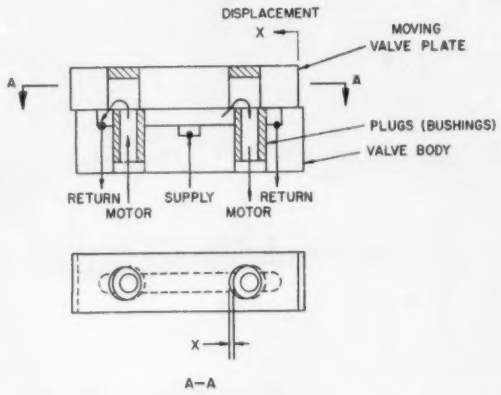

Fig. 8 — Flat-plate four-way valve, plugged-hole construction.

Single-Stage Versus Multistage Operation and Valve Forces: Single-stage valves are attractive because they contain far fewer parts than the multistage valve. The single-stage valve consists of the valve actuator, the flow valve and the motor. The two-stage valve, in addition, must have a second-stage flow valve with a feedback means for the second stage. Single-stage electrohydraulic servo valves with power outputs of the order of 6 hp have been built and operated successfully. These valves, having response times on the order of a few milliseconds, were used as high-speed servo valves for airborne application. Experience has shown, however, that the spool type valves of such applications have to be designed with flow-force compensators which add significantly to the cost of the valve.

Flow-force compensation devices reduce the flow-induced valve forces to a level where the conventional electromagnetic valve actuator will operate reliably. Power levels above 6 hp at the load require multistage servo valves, as flow forces become large.

Flow-induced valve actuating forces for a four-way valve with square ports are given by:

$$F = 0.0064\ Q\sqrt{P_v}$$

where F = valve operation force, lb; Q = flow to the load, cu in. per sec; and P_v = pressure drop across valve, psi. Specific gravity of fluid is 0.85. A supply pressure of 3000 psi and a flow to the valve of 5 gpm results in an uncompensated force, F, of 4.0 lb, which has to be overcome by the valve actuator. (Supply power 8.75 hp, power to the load 5.75 hp.)

In addition to the hydrodynamic valve forces, appreciable friction forces from dirt and hydraulic side loads have to be overcome. These sticking forces may be on the order of several pounds depending on the cleanliness of the system. As a result, present practice limits the use of single-stage valves to 2 hp or less.

Valve Actuation: The simplest valve actuator is a simple mechanical linkage. This method requires a force or position input signal of a sufficiently high force level. Automotive steering boosters, aircraft booster controls, some ship steering boosters, and certain machine-tool and process controls fall in this category. In many instances, such as machine-tool tracers, missile and aircraft autopilot controls, and radar and gun-turret controls, the input signal is in the form of a low-power electrical signal which has to be transduced into a force or position signal of sufficient magnitude to move the valve by an electromechanical valve actuator. The following basic types have received some attention:

1. Electromagnetic
2. Magnetostrictive
3. Piezoelectric

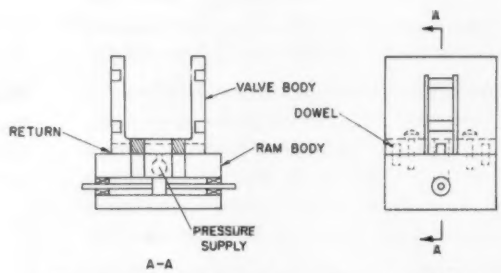

Fig. 9—Suspension valve, using plug and hole construction.

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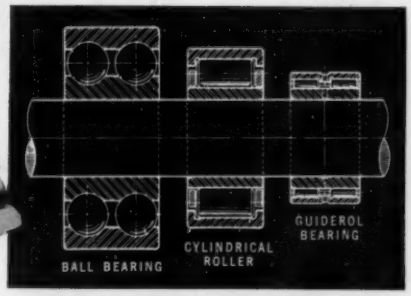
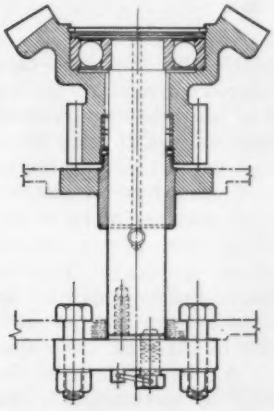


Showing graphically how a McGill GUIDEROL precision needle bearing permits more streamlined designing by supporting comparative loads in significantly smaller radial space than other types of bearings. Bulky and more costly housing space is easily avoided.

The McGill GUIDEROL Bearing combines the inherent high-load capacity of a full complement of full race width rollers with a center roller guiding principle that limits skewing and binding under misalignment. This qualifies the bearing for a whole range of applications that are too heavily loaded for a retainer-type bearing and are subject to the misalignment that precludes use of an ordinary needle bearing. For outstanding performance in small radial space, use GUIDEROL precision needle bearings. Specify the interchangeable sealed SGR series for added protection against contamination.

GUIDEROL® *bearing capacity, space economy proved in power shovel vertical reversing shaft assembly*

Baldwin - Lima - Hamilton Corp. uses a McGill GUIDEROL bearing, on ½ cubic yard power



shovels, to carry spur pinion loads in the vertical reversing shaft. The high capacity of the bearing in small radial space is an important factor in selection of this bearing. Only 3.75″ in diameter, it has a load capacity of 28,560 lbs. at 100 rpm. In the power shovel application, it supports 14,150 lbs. at 76.3 rpm, which gives a high margin of safety. The center guided rollers also are especially adaptable to a vertical application such as this.

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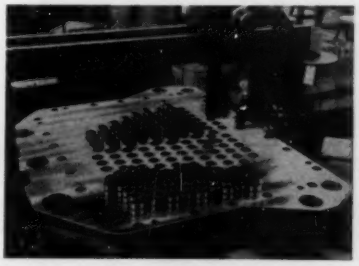

Multiple spindle drill heads require support of spindles on very close centers

Crowding a great number of drill spindles into a small area, Zagar, Inc., of Cleveland has found the McGill GUIDEROL bearing construction especially suited to the needs of multiple drill head units. The full bearing width rollers provide rigidity and more than adequate load capacity and in a bearing only 1.25″ in bore diameter.

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The electromagnetic type has proved to be the most successful and widely used; of the other two, the magnetostrictive is limited by the small motions which are available and the piezoelectric is limited by the high operating voltages which are required and the inability of piezoelectric materials such as barium titanate or Rochelle salt crystals to withstand the high temperatures to which hydraulic systems are subject.

The electromagnetic valve actuator is either of the solenoid or torque-motor type.

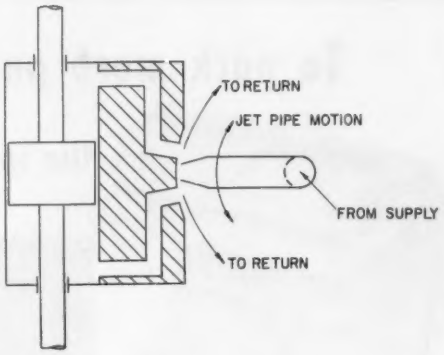

Fig. 10 — Jet-pipe valve.

Feedback Means: Most of the valve-controlled hydraulic servomechanisms work as position controllers. Since a position change of the pilot spool valve of a two-stage unit results in an acceleration of the output stage, the position of both the power stage and the output stage have to be fed back and compared to the input signal. In other words, two integrations have to be "wiped out."

Mechanical feedback means may consist of:

1. Movable sleeve or valve body. This is a simple method which, however, is limited in its usefulness by the fixed feedback gain of the unit and the large inertia which has to be moved.
2. Force feedback through a spring, accomplished by connecting the second stage to the pilot stage by a spring so that in the final position, the spring force equals the actuator force.
3. Pressure feedback. In this system, pressure across the load is caused to act on the pilot stage to oppose the force from the valve actuator. Pressure feedback happens to be built into the spool valve; a very considerable and controllable amount exists in the seating type valves. Additional pressure feedback may be built into a valve. Attention is drawn to the strong stabilizing effect of pressure feedback on the performance of most hydraulic servomotors.

Electrical feedback is accomplished by variable differential transformers, synchros or potentiometers. The majority of electrohydraulic servovalves use one form or another of electrical feedback, yet the simplicity of the mechanical feedback possibilities should not be overlooked.

From a paper entitled "Design and Operation of Valve Controlled Hydraulic Servomechanisms" presented at the National Conference on Industrial Hydraulics in Chicago, October, 1956.

Data Storage Media

for automatic controls

By George F. Baldwin and H. L. Tholstrup

General Electric Co.
Utica, N. Y.

Commercial Controls Corp.
Rochester, N. Y.

THE three storage media in most common use for automatic data handling are perforated tape, perforated cards and magnetic tape. Each has distinct advantages and no one or two is likely to replace the need for the others.

Perforated Tapes: Perforated-tape handling equipment is somewhat simpler, less expensive, and smaller than magnetic-tape equipment. It is somewhat comparable in complexity to card-handling equipment, but again is smaller. Coding is normally accomplished in code groups perpendicular to the length of the tape and readers normally read one code group at a time. Tapes with five, six, seven, or eight channels are commercially available. The 15-channel tape was developed for military applications and is not presently available for commercial use. If more than eight bits of parallel information are required, some form of intermediate storage may be employed with sequential code groups stored and read out in parallel. Tape feed is accomplished by a sprocket driving the feed holes located near the center of the tape. Code holes are on a 0.1 by 0.1-in. grid. Storage density is therefore 100 bits per sq in. Tape reading speeds vary from 1 to 6 in. per sec with mechanical readers, to 40 in. per sec with photoelectric readers. Punch speeds vary from 1 to 6 in. per sec. Tape reels hold up to 2000 ft of tape, and by fanfolding the tape, lengths to 3000 ft may be handled.

The holes in most tapes are com-

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pletely perforated circles, but several manufacturers are using "chadless" tapes in which the holes are only partially perforated. Chadless tapes offer an advantage whenever it is desirable to write on the tape. One manufacturer is developing a punch which produces rectangular perforations but which can be read by machines designed for round holes.

The most common material employed in perforated tape is 0.004-in. thick wood sulfide paper, usually impregnated with paraffin-base oil. In all, some 30 or more materials have been used. Some of these are vegetable parchment, electrical insulation grade fiber, plastic tapes, and laminates of plastic with other materials, such as rope-fiber paper. Among the plastic tapes, the polyesters such as Mylar predominate at present.

The major problem in standardization of perforated tapes lies in the area of dimensions and tolerance. Although standard widths and the 0.1 by 0.1-in. grid spacing have been almost universally adopted, differences in locations of feed holes, dimensional references, and hole diameters and tolerances vary to the extent that some tapes prepared in a machine built by one manufacturer can not always be read accurately by machines built by other manufacturers, particularly in the case of high-speed devices. Attempts are now being made among individual manufacturers of tape-handling equipment to achieve some form of standardization.

Perforated Cards: The perforated-card situation is somewhat less confused, with only three that have achieved much distribution. The 80-column IBM card is in most common usage. Alphanumeric information is contained in 12 rows of rectangular holes with each card capable of storing 80 code groups or characters. Since this compares with 8 in. of ⅝-in. wide perforated tape, insofar as alphanumerical data-handling capability is concerned, it is apparent that the storage density is appreciably less than that of perforated tape.

Card-reading rates vary from 250 to 900 cards per min, and punches handle from 155 to 450 cards per min. The maximum information rates are, therefore: in reading, 1200 characters per sec; in punching, 600 characters per sec. This compares with a maximum reading speed of 400 characters per sec by photoelectric tape readers, or an advantage in information rate (over punched tape) of about three to one. Perforated cards are particularly attractive whenever there is a requirement for rapidly searching through large quantities of stored data for desired information. Card sorters will handle 1000 cards per min.

The second most commonly used card, the 90-column Rem-Rand card, is arranged in two groups of 45 columns each with six code holes per column. The card dimensions are the same as the 80-column card (3¼ by 7⅜ in.), but the cards are in no way compatible as regards handling equipment. Reading speed for the 90-column card is 800 cards per min, and cards are punched at the rate of 135 cards per min. Translators are available for conversion from 80 to 90 and from 90 to 80-column cards.

The Underwood-Samas card is somewhat smaller than the others, only 2 by 4 11/16 in. It is a 40-column card.

Magnetic Tapes: Magnetic tapes, though a relative newcomer to the field of storage media, are in such a rapid state of development that it is somewhat difficult to detect a trend which might be adopted for standardization. They achieve greatest utility whenever high storage density and information rates are required. Established techniques permit maximum storage density of about 200 bits per linear in. of tape with 120 to 125 bits per in. common. Techniques now under development may increase this further. Tape transports which handle tape at rates from ½ to 80 in. per sec with the majority at 7½ to 15 in. per sec have been designed. This combination represents a potential capability of handling 16,000 characters per sec. However, it is believed that the highest combined operation in use to date is about 10,000 characters per sec (125 characters per in. at 80 in. per sec). High tape speed of course results in shorter time per reel. With tape reels currently capable of handling from 200 to 4800 ft of tape, the maximum playing time at 80 in. per sec would be only 12 min.

Tapes have been manufactured in various widths from ¼ to 15 in. A width of ½ or ⅝-in. is commonly used for seven channels, 1 in. for 14 channels, and 1¼ in. has been used for 28-channel tape. Most tapes range in thickness of from 1 to 2 mils, with 1 mil tape becoming predominant, since it permits more tape per reel. Approximately 3600 ft of 1 mil tape or 2400 ft of 1½-mil tape may be placed on a standard 10½-in. NARTB reel.

Normally, one channel of the tape is reserved for a synchronization or timing channel, since the high storage density precludes the use of mechanical synchronization. Some so-called seven-channel tapes actually have an eighth channel reserved for this purpose. One metallic tape uses a sprocket drive.

Until recently, the most common base material has been cellulose acetate, but polyesters such as Mylar are coming into wide use. Polyesters are about 1½ times more stable under variations in temperature, nine times more stable with humidity, approximately five times more resistant to impact, and nine times more resistant to tearing than is cellulose acetate.

Several thousand different combinations of magnetic coatings have been developed. In general, thick coatings provide higher dynamic range and thin coatings give a higher frequency response, permitting higher information rates. One-mil thick polyester-base tape with 0.3 to 0.4-mil magnetic coating appears to be best suited to machine-control requirements.

Other Media: Many other storage media such as magnetic drums, perforated and magnetic discs, and photographic films have been employed for various applications, but it does not appear that they will find direct application for machine control in the immediate future.

From a paper entitled "Computer Elements Available for Machine Tool Use" presented at the AIEE Machine Tool Conference in Cincinnati, October, 1956.

VICTOR TORCH with cutting tip of Anaconda Tellurium Copper, which has the resistance to heat and wear required to maintain uniform flame characteristics through a long life of service.

Tellurium Copper makes better cutting and welding tips

Two typical Victor torch tips of Anaconda Tellurium Copper-127 shown full size.

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Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Water Filters

"Fulflo Filters for Water and Aqueous Liquids" is title of booklet GEO-501 which provides data on models with deliveries from 2 to 710 gpm. Operating pressures, tube lengths, pipe sizes, inlet-outlet sizes, height and weight are also covered. 4 pages. Commercial Filters Corp.

Circle 651 on page 19

Screw Conveyor Components

Ball bearing equipment designed to fit new or existing screw conveyors is subject of folder 2489. Technical data on selection and application of Quik-Link conveyor screws, trough ends and hangers are detailed, as are solutions to drive end space problems. 6 pages. Link-Belt Co.

Circle 652 on page 19

Electrical Input Control

Detailed design information is provided in data sheet J-31A on the Atcotrol manual set input controller for electrically heated ovens, furnaces, dryers, evaporators and dehumidifiers. Controller replaces rheostats and eliminates power waste. 4 pages. Automatic Temperature Control Co.

Circle 653 on page 19

Air Pumps & Motors

Leiman rotary positive air and vacuum pumps, gas booster and air motors are detailed as to construction, dimensions, capacities, performance and installation in catalog 1957. 16 pages. Leiman Bros., Inc.

Circle 654 on page 19

Plastic Caps & Closures

Data sheets and actual samples are included in revised file folder on expanded line of CaPlug threaded and nonthreaded polyethylene caps and plugs. Dimensions and prices cover over 300 stocked sizes used to protect tubing, valves, machined parts and fittings. 16 pages. Protective Closures Co.

Circle 655 on page 19

Belt-Cleaning Brushes

Designed to clean rubber or fabric conveyor belts, Rota-Master brushes are made in 16, 18 and 24-in. widths. They can be used in series to any width. Brushes are also suited for material spreading, dust removal and metal finishing when used with abrasive compounds. Full details are given in catalog. 4 pages. Osborn Mfg. Co.

Circle 656 on page 19

Bearing Lubrication

Special relief-type lubrication fitting described in bulletin BU-61 is easily attached to bearing housings of motors, machines or pillow blocks having relief plugs. It shows how fitting saves time and helps prevent over-lubrication of ball and roller bearings. 4 pages. Keystone Lubricating Co.

Circle 657 on page 19

Silicone Fluids

Reference brochure 3-106 on physical and electrical characteristics of silicone fluids aids designers in evaluating their specific uses. Data cover specific gravity, pour point, thermal conductivity, surface tension, refractive index, dissipation factor and specific heat. 4 pages. Dow Corning Corp.

Circle 658 on page 19

Electronic Test Components

Facilities available for the manufacture of electronic test equipment component parts, custom manufacture of complex electronic devices, and electronic research and development are described in illustrated brochure "Research - Development - Manufacture." 12 pages. Laboratory for Electronics, Inc.

Circle 659 on page 19

Hydraulic Pumps & Motors

Rotary pumps with capacities ranging from 75 gpm at 1000 psi to 375 gpm at 100 psi as well as hydraulic pump-motors for high torque, low speed power transmission in mobile and industrial equipment are subject of catalog 957. Also offered is revised booklet "How to Solve Pumping Problems" which contains charts, performance data and other information on rotary gear pumps. 12 and 36 pages, respectively. Geo. D. Roper Corp.

Circle 660 on page 19

Mechanical Seals

Written for designers and manufacturers of processing equipment, catalog 480 gives complete selection and application guidance on line of rotary mechanical seals. Cut-away views show stuffing box installation details. Reference data are given on temperatures, pressures and fluids served. 20 pages. Durametallic Corp.

Circle 661 on page 19

Air Control Valves

Pilot-operated poppet type air control valves for pneumatic equipment are subject of catalog 105. Full information is given on two, three and four-way operation, with master (air), single or double solenoid pilot control. Pipe sizes range from ¼ through ¾-in. 16 pages. Galland-Henning Nopak Div.

Circle 662 on page 19

Copper & Copper Alloys

Two manuals are available which cover machining of 43 standard copper and copper-alloys. Manual B-3 covers "Machining Copper and Copper Alloys," while manual B-14 discusses "Rods for Screw Machine Products." Brass, Everdur, phosphor bronze, commercial bronze, nickel silver and copper are covered. 32 and 25 pages. American Brass Co.

Circle 663 on page 19

Clutches & Brakes

"Fawick Standardized Press Application" is title of design guide book No. ML-172 which contains engineering, dimensional and performance data on the improved line of clutches and brakes for use on presses of all types. These automatic units provide for automated control of machine. 26 pages. Fawick Corp., Fawick Airflex Div.

Circle 664 on page 19

Indexing Drives

Details of the new line of series E Ferguson roller gear drives for precision indexing of O.E.M. equipment and instruments with low torque requirements and a need for indexing rates up to 2000 rpm are given in bulletin 107A. Nineteen standard units have 3 to 12 stops and indexing periods of 120, 180 and 270 degrees.

New Rokide* Coatings Resist Heat and Abrasion

Rokide spray coatings help solve many high temperature and wear problems

WITH the rapid increase in modern high temperature applications there has been a corresponding increase in demands for resistant materials. Norton ROKIDE spray coatings are meeting such demands with great success. These hard, adherent crystalline refractory oxides offer many important advantages. For example:

They are both thermally and electrically insulating . . . Their hardness, chemical inertness and stability in combustion temperatures provide high resistance to excessive heat, abrasion, erosion and corrosion. Their high melting points and low thermal conductivities reduce the temperatures of the underlying materials and permit higher operating temperatures.

ROKIDE Coatings vs. Stainless Steel

Analyses of Norton ROKIDE spray coatings and of stainless steel reveal interesting comparisons. While less dense than the bare steel, the ROKIDE coatings are very much harder, have considerably higher melting points and are very much lower in thermal conductivity and thermal expansion.

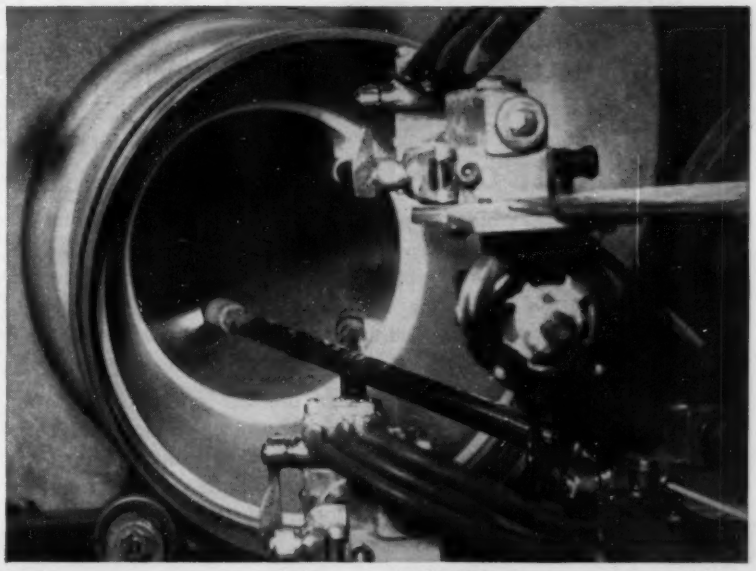
Proof

There are three Norton ROKIDE coatings: ROKIDE "A" aluminum oxide, ROKIDE "ZS" zirconium silicate and ROKIDE "Z" stabilized zirconia. These have been proved in such critical applications as reaction motors, as well as in AEC projects.

ROKIDE spray coatings are also helping to solve industrial problems involving: Electrical insulation • Thermal barriers • Electronic applications • Bearing surfaces • Erosion protection • Corrosion retardation • Chemical barriers • Positioning medium • Material up-grading • Altering emissivity and characteristics of surfaces • Surface catalytic activity • General wear resistance.

Although ROKIDE coatings are most commonly applied to metals they are effective on other materials, such as ceramics and certain plastics. Thicknesses of the coatings generally range from .005″ to .05″.

For more detailed information on ROKIDE coatings, write to: **NORTON COMPANY,** ***New Products Department,*** Worcester 6, Mass.



ROKIDE Spray Coatings are applied in a molten state by means of a metalizing type spray gun*. The oxide is fed into the gun in rod form at a carefully controlled rate. The coatings can be applied to parts of any size and to all shapes accessible to the spray gun equipment. Multiple gun set-up shown in illustration.

NORTON

NEW PRODUCTS

Making better products... to make your products better

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

Facilities for applying ROKIDE coatings available at:
NORTON COMPANY
Worcester, Massachusetts
and
2555 Lafayette Street, Santa Clara, California

* Manufactured by Metallizing Company of America, Chicago 32, Ill.

Circle 490 on page 19

Helpful Literature

4 pages. Ferguson Machine Corp. of Indiana.

Circle 665 on page 19

Speed Reducers

Complete information on concentric shaft and right angle speed reducers for applications up to 140 hp or 72,000 lb-in. of torque output is presented in engineering bulletin 1105. Design data are given on units with ratios ranging from 1.49:1 up to 1459:1. 24 pages. Falk Corp.

Circle 666 on page 19

Hydraulic Pilot Valve

Catalog section 11 describes No. 811 and 811R (reverse acting) spring loaded, diaphragm actuated hydraulic pilot valves. Designed to control diaphragm valves used as reducing or unloading valves, the 811 responds to a 1-psi variation in the flow line. 2 pages. Atlas Valve Co.

Circle 667 on page 19

High-Temperature Alloys

Engineering properties and fabrication characteristics of ten high-strength alloys for elevated-temperature service are presented in illustrated data book. Recommended uses and design information are given for each alloy. How to use stress-rupture and creep data is discussed. 20 pages. Carpenter Steel Co.

Circle 668 on page 19

Gages, Thermometers & Recorders

Accessories for use with various types of gages, dial thermometers, recorders and controllers for processing and general industrial service are described in illustrated bulletin 600. Included are attachments for protection against corrosive media and pressure pulsations. 4 pages. American Machine & Metals, Inc., U. S. Gauge Div.

Circle 669 on page 19

Gear Honing

Illustrated bulletin H-57-2 discusses the new Red Ring gear honing process which improves the sound qualities of hardened spur and helical gears by removing nicks and burrs, improving surface finish and correcting minor heat treatment distortions. Details of 8 and 12-in. gear honing machines are given. 4 pages. National Broach & Machine Co.

Circle 670 on page 19

Stamping Data

"Need a Helping Hand on Stampings?" is title of guide to the stamping facilities of this company for production of all sizes and types of

Breaking fabrication barriers in new materials with cold forging!

Magnesium, Oxygen-free Copper, Zirconium, High Strength Aluminum Alloys

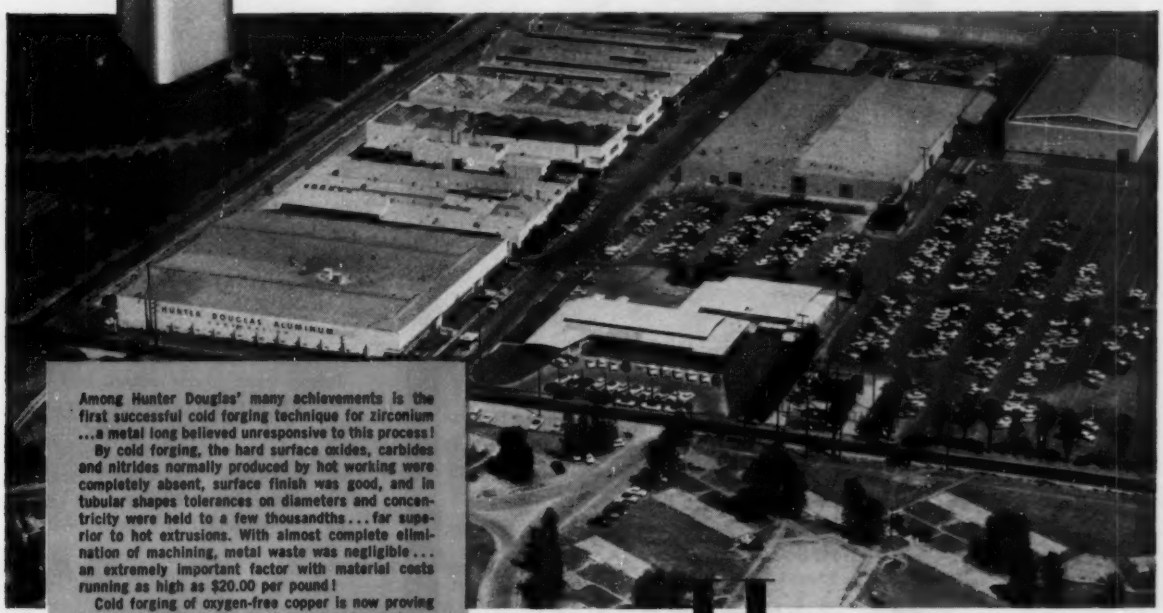
Most companies and engineering personnel are well acquainted with Hunter Douglas' activities in the field of cold forging aluminum and aluminum alloys. Not so well known are our efforts in the production of magnesium and oxygen-free copper components by the same process. Recently, as the result of a concentrated Hunter Douglas research program, tubular zirconium was successfully cold-forged...an achievement which now opens the door to the fabrication of other rare and costly metals by our cold forging techniques.

The field of cold forging is constantly expanding with many new successes destined for the future.

Where stakes are high and being "first" assures a competitive advantage—in lower cost, better design, greater strength—an original approach to your fabrication problem will pay dividends.

Hunter Douglas cold forging techniques, backed by an unmatched experience in this field, frequently supply the missing key. Many fabrication problems can be solved simultaneously by producing hollow, dense, zero-draft components meeting exact part geometry requirements and difficult performance specifications.

If you have production requirements in any of the metals now being regularly cold forged, we welcome the opportunity of reviewing prints and submitting quotations. Especially important, *if you have an advanced program involving zirconium or other rare metals,* we are in position to devote development facilities to the solution of specific high priority problems.



Among Hunter Douglas' many achievements is the first successful cold forging technique for zirconium ...a metal long believed unresponsive to this process!

By cold forging, the hard surface oxides, carbides and nitrides normally produced by hot working were completely absent, surface finish was good, and in tubular shapes tolerances on diameters and concentricity were held to a few thousandths... far superior to hot extrusions. With almost complete elimination of machining, metal waste was negligible... an extremely important factor with material costs running as high as $20.00 per pound!

Cold forging of oxygen-free copper is now proving important to the electronics industry and experimental development work is in progress on magnesium and even common metals, such as steel. Out of this extensive research program is coming the vital knowledge for meeting tomorrow's unusual problems. Look to Hunter Douglas for everything new in cold forging!

Hunter Douglas Aluminum Corporation

Hunter Douglas Aluminum Corporation • Dept. MD-4, Riverside, California, Overland 3-3030

Helpful Literature

stamped products and assemblies. Typical customer-specified products are shown in bulletin Adv. 681. 16 pages. Republic Steel Corp., Pressed Steel Div.

Circle 671 on page 19

Lock Nuts

American Standard dimension tables on all M-F lock nuts and semi-finished nuts, as well as data on wrench torques and test procedures for torque type lock nuts are contained in catalog. New two-way lock nut is also described. 12 pages. MacLean-Fogg Lock Nut Co.

Circle 672 on page 19

Magnetizers

Data and charts relative to electromagnetic and permanent-magnet type magnetizers are provided in bulletin 17. Information includes directions on how to use these magnetizers. 2 pages. Indiana Steel Products Co.

Circle 673 on page 19

Fluorescent Lighting

Sections on advantages of fluorescent lighting and development of fluorescence, including chapters on lamp types, starters, lampholders, ballasts and special lamps are featured in "Fluorescent Lighting Guide Book" No. FL-578. 24 pages. Sylvania Electric Products Inc.

Circle 674 on page 19

Power Steering System

New Air-O-Matic 500 series power steering system for highway and heavy-duty vehicles is subject of descriptive brochure. Heart of system is air-actuated cylinder that pushes and pulls steering linkage with the right force for each driving condition. 4 pages. Air-O-Matic Power Steer Corp.

Circle 675 on page 19

Ammeter

Easily read linear scales and high accuracy are features of Beckman alternating current ammeter described in illustrated data sheet 839. Dial markings are evenly spaced. Specifications and dimensional drawings are included. 2 pages. Helipot Corp.

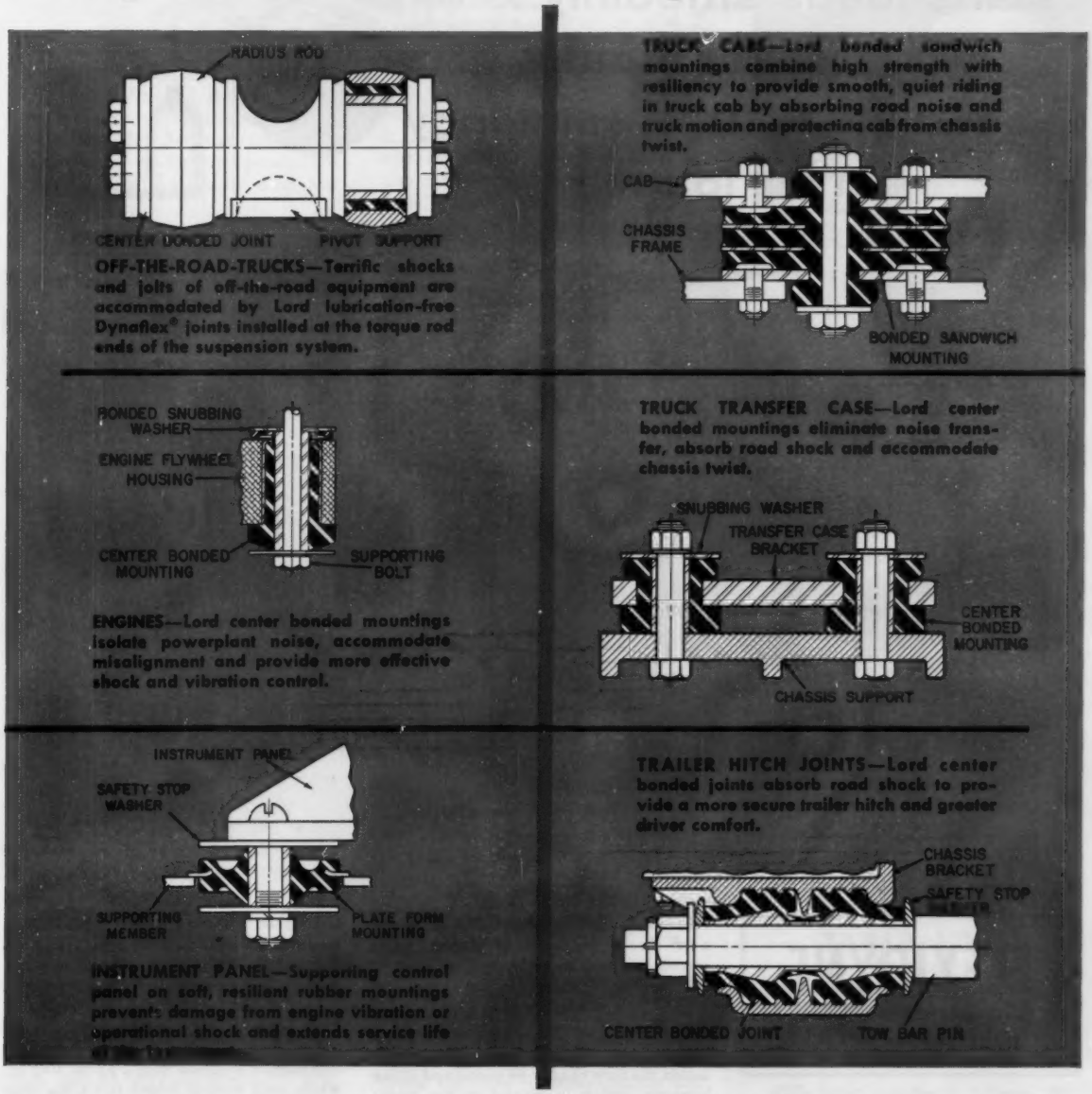
Circle 676 on page 19

Pressure Indicator

Swiss SLM pressure indicator described in illustrated data sheet consists of quartz crystal pickup, cable and amplifier-calibrator unit. One

Circle 493 on page 19

LORD bonded rubber mountings improve automotive performance



These are only a few of the many successful automotive applications designed by Lord. Each vibration control system is engineered to meet the specific installation requirements.

Find out how Lord bonded rubber mountings and joints can reduce noise, frictional wear, metal-to-metal contact, maintenance and lubrication. Lord Field engineers are located in major industrial centers. Call or write the Lord office nearest you.

ATLANTA, GEORGIA - CEdar 7-1123
BOSTON, MASS. - HAncock 6-9135
CHICAGO, ILL. - MIchigan 2-6010
CLEVELAND, OHIO - SHadyside 9-3175
DALLAS, TEXAS - RIverside 1-3392
DAYTON, OHIO - MIchigan 8871
DETROIT, MICH. - TRinity 4-2060
LOS ANGELES, CAL. - HOllywood 4-7593
NEW YORK, N. Y. - CIrcle 7-3326
PHILADELPHIA, PA. - LOcust 4-0147

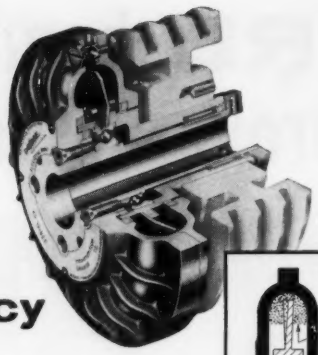
"In Canada—Railway & Power Engineering Corporation Limited"

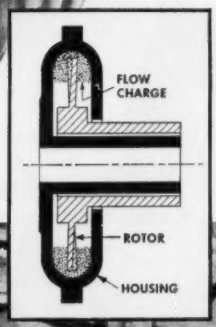
LORD MANUFACTURING COMPANY • ERIE, PA.

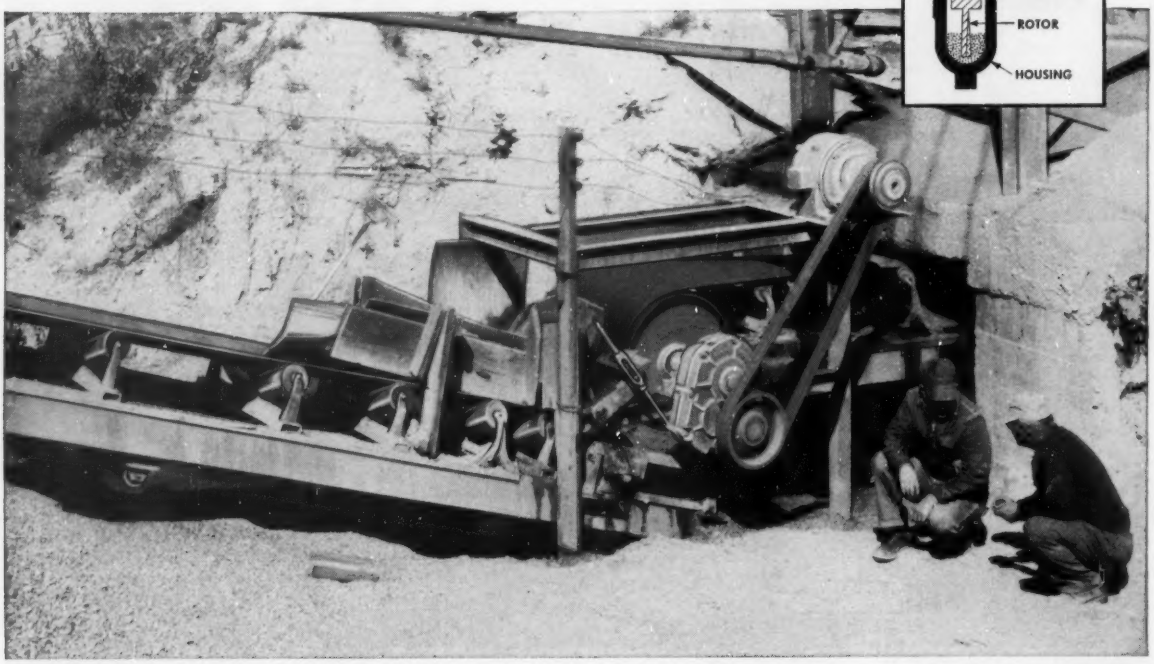
LORD BONDED RUBBER

designers and producers of bonded rubber products since 1924

This new drive starts loads smoothly... with smaller motors ...and gives 100% efficiency at full load!







FLEXIDYNE

THE DRY FLUID DRIVE

This tunnel conveyor, 225 feet long, handles 500 tons of sand and gravel per hour—8 to 16 hours a day.

With Flexidyne, the motor picks up the load easily and smoothly. Power investment is reduced, power costs cut, maintenance simplified and conveyor belts are protected against breakage.

Flexidyne, the Dry Fluid Drive, is the *new* development that starts loads smoothly, that protects against shocks and overloads, that saves power and that gives 100% efficiency at full load!

The "dry fluid" in Flexidyne is heat treated steel shot. A measured amount, called the flow charge, is contained in the housing, which is keyed to the motor shaft. When the motor is started, centrifugal force throws the flow charge to the perimeter of the housing, wedging it between the housing and the rotor which transmits power to the load.

After a momentary slip between housing and rotor, the two become locked together and achieve full load speed without slip and at 100% efficiency during the running cycle. Changes in weather—hot or cold—inside or out—do not affect operation of Flexidyne.

Flexidyne is now available in 8 sizes—for use with electric motors and internal combustion engines from 1 hp to 300 hp. While each size is power rated, the flow charge can be varied at will to give tailor-made torque for your particular job. Write for Bulletin A-640.

DODGE MANUFACTURING CORPORATION
3300 Union Street, Mishawaka, Indiana

CALL THE TRANSMISSION ENGINEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in your classified phone book, or write us.

DODGE
of Mishawaka, Ind.

transducer is used for ranges from 0.1 to 3000 psi. Specifications are detailed. 2 pages. Kistler Instrument Co.

Circle 677 on page 19

Time Delay Relays

Selection information on hermetically sealed Agastat time delay relays is found in illustrated bulletin SR-5R. Data on five basic SF models are presented and their operation is described. 4 pages. Elastic Stop Nut Corp. of America, AGA Div.

Circle 678 on page 19

Lubricators

Design and operation of semiautomatic spring discharge piston pump lubricators are found in service instruction sheet. Type L one-shot system is operated by button or lever. Applications are covered. 2 pages. Bijur Lubricating Corp.

Circle 679 on page 19

Thermostat

Electric domestic oven temperature control with an auxiliary top-heat switch for use on domestic cooking ranges is described in illustrated bulletin RT-786. Operational data are included, along with specifications. 4 pages. Robertshaw-Fulton Control Co.

Circle 680 on page 19

Fluid Power Devices

Briefly described and illustrated in folder are air and hydraulic cylinders, air and hydraulic valves and packaged units, including machine controls, kick press conversion kits, air collet chucks, portable air compressors, flow control valves and others. 4 pages. Modernair Corp.

Circle 681 on page 19

Sealing Materials

Specialized mechanical sealing materials described in illustrated bulletin include Sirvene synthetic rubber compounds and Sirvis and Sirvis-Conpor mechanical leathers. Products covered include shaft and end face seals, molded parts, mechanical cups, packings, gears, boots and way wipers. 12 pages. Chicago Rawhide Mfg. Co.

Circle 682 on page 19

Conveyors

Use of Rapistan gravity and power belt conveyors in various industrial operations is shown in illustrated bulletin IND-1. It describes use of basic packaged conveyor units, portable lines and controlled flow systems. 4 pages. Rapids-Standard Co.

Circle 683 on page 19

Stainless Steel

Mechanical properties of 17-4 ph precipitation hardening stainless steel are presented in Esco Alloy Notebook No. 5. Data are given for hardening at temperatures from 800 to 1200°F for cast and wrought samples. Other technical data are also included. 12 pages. Electric Steel Foundry Co.

Circle 684 on page 19

Synchronous Motors

Bearings that require no lubrication and which are suited for use up to 165° F are built into synchronous timing motors described in illustrated data sheet 150. Specifications, features and uses of motors are covered. 2 pages. Lux Clock Mfg. Co.

Circle 685 on page 19

Over 4000 Fasteners

Broad variety of socket screw, cap screw and related fasteners—over 4000 in number — is described and illustrated in folder. Carbon restoration process for all heat treated products is described. 6 pages. Chicago Screw Co.

Circle 686 on page 19

Timing Devices

Basic engineering data on the 70,000 series Mark-Time timing devices are provided in catalog sheet BX-219. Variety of switching arrangements and features are shown on illustrated chart. 2 pages. M. H. Rhodes, Inc.

Circle 687 on page 19

Air Control Valves

Dimensional data, parts lists, descriptive information, price list and flow diagrams for Starline series of air control valves are contained in data file. Series includes five pilot heads that are interchangeable with seven valve bodies. Various valve configurations are described. 71 pages. Ross Operating Valve Co.

Circle 688 on page 19

Printed Circuit Laminate

Cirprint copper-clad laminate developed for printed circuit use is detailed in illustrated folder 755. Material exceeds NEMA standard for XXP and meets military specifications. Properties and comparative data for other laminate grades are included. 4 pages. Formica Corp.

Circle 689 on page 19

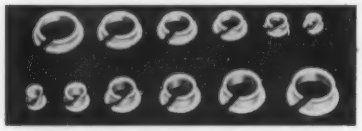
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Nylon Bearings

have helical split for snap-in action

Type 7 Nyliners are flanged on both ends to retain bearing in a hole in sheet metal or thin plates of any material. Bearings are provided with a helical split equal in width to expansion and contraction of nylon due to temperature changes and moisture absorption. This prevents changes in bore di-



ameter and permits close fits of shaft to bearing. It also allows bearing to be collapsed sufficiently to allow anchoring flange to pass through mounting hole. Bearings have low friction and are corrosion-proof, noncontaminating and operate in most liquids. Units are available in two lengths for plate thickness from 0.040 to 0.075 and 0.072 to 0.135-in. There are nine sizes of each, and bore diameters range from ⅛ to ¾-in. **Thompson Industries Inc.**, Manhasset, L. I., N. Y.

Circle 690 on page 19

Quad Ring Seals

new process gives large diameters

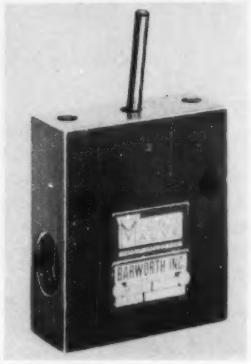
Quad Ring seals with cross-sections from 0.070 to 0.275-in. are available in any diameter. New molding method also maintains normal, close cross-sectional tolerances. Designed with no parting line on sealing edges, rings eliminate spiral twist failures, rolling with pulsating pressures and leakage at low pressure differentials. They are effective for reciprocating, rotary and static uses. **Minnesota Rubber & Gasket Co.**, Dept. KP-3, 3630 Wooddale Ave., Minneapolis 16, Minn.

Circle 691 on page 19

Snap-Action Valve

is small in size and lightweight

Model 167 Micro Valve is used in air, gas, oil and water services. A three-way, two-position valve,



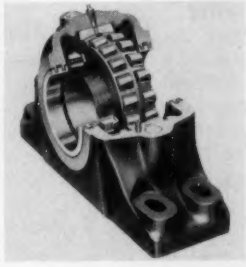
it is small, lightweight and employs snap-action control. Operating pressures are from 0 to 100 psig. Valve is stainless steel, aluminum and synthetic rubber. It is 1½ in. wide, 1¾ in. high, ⅝-in. thick, and weighs 2 oz. **Barworth Inc.**, 7 Industrial Place, Summit, N. J.

Circle 692 on page 19

Pillow Blocks

are mounted easily on shafts

Spherical roller bearing pillow blocks, designated Spher-Align, can be mounted solidly on shafts quickly and easily through the use of setscrews located parallel to the bore in adapter nut. After bearing is tightened with adapter nut, adjustment is completed by turning setscrews against locking washer until bearing, adapter and shaft form an integral unit. Housing of the pillow block is close-grained semisteel to withstand shock loads. Lubricant enters at



the center of the bearing and moves outward along all bearing surfaces. Drain plugs permit use of either grease or oil and provide for easy flushing. Triple seals retain lubricant. Pillow blocks are available in both expansion and nonexpansion types and fit shafts from 2 7/16 to 8 in. in diameter. **Dodge Mfg. Corp.**, Mishawaka, Ind.

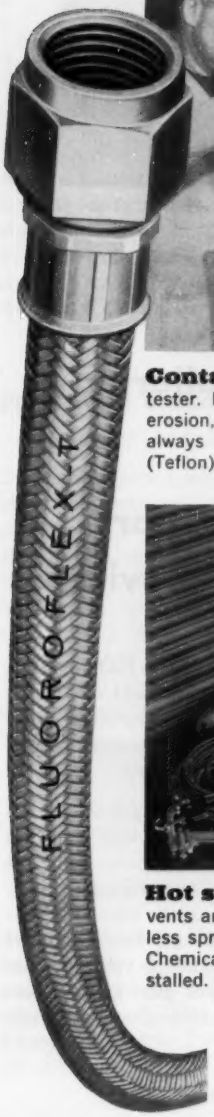
Circle 693 on page 19

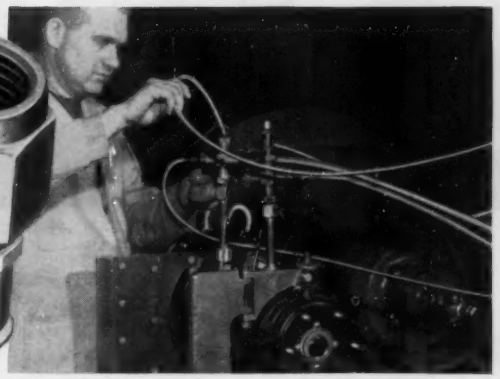
Self-Sealing Coupling

for portable cylinder applications

Series 5104 LP-gas self-sealing coupling is recommended for portable cylinder applications, such as in industrial lift trucks, domestic LP-gas installations, home and house-trailer units, and commercial and industrial installations. The coupling can be diconnected or connected by hand even when lines are pressurized. Union nut

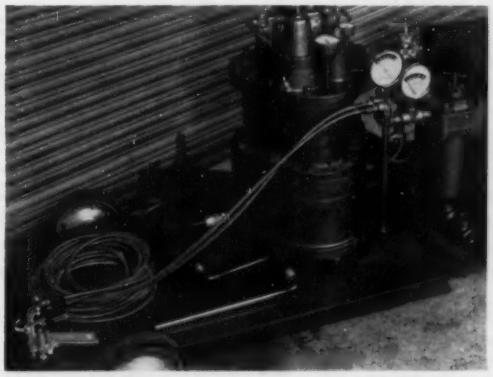
Do you have any of these flexible hose problems?



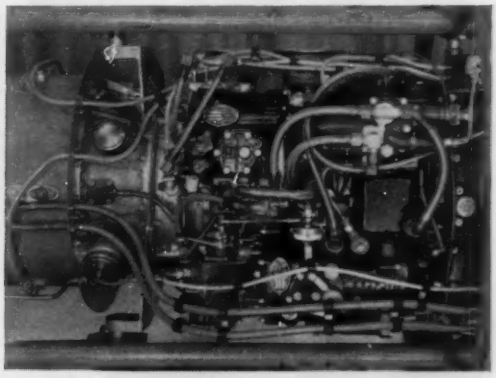


Contamination. This is a hydraulic equipment tester. Lines used previously contaminated the oil by erosion, required excessive replacement. Now fluid is always clean because chemically inert Fluoroflex-T (Teflon) hose assemblies neither corrode nor erode.

Excessive flexing. Ordinary hose on a plastic molding press, subjected to heat plus constant flexing on 50-second cycle 22½ hours a day, lasted three months. Then Fluoroflex-T (Teflon) hose assemblies were tried. Even after three years, there were no failures.



Hot solvents. Finishes using strong organic solvents are sprayed hot at 500 to 600 psi with this airless spray equipment. Ordinary hose failed frequently. Chemically inert Fluoroflex-T hose assemblies were installed. Record shows no failures after 2 years service.
(Photo courtesy Bede Products, Inc.)



High temperature. While conveying active fuels and oils, the plumbing of a jet engine is also exposed to high temperatures. Ordinary hose fails fast in this service. Fluoroflex-T hose assemblies have now had over 4 years of flight service, are specified for virtually every jet engine.

Most flexible hose problems are quickly solved for good by Fluoroflex®-T hose assemblies with the original, patented Teflon® tube. Consider these qualifications: non-aging; completely inert; flexible over entire continuous operating range of –65°F to +450°F; lightweight; small O.D.; 1000 psi working pressures; stainless steel outer braid; and blowoff-proof fittings. Send for data.

® *Teflon: DuPont trademark. Fluoroflex: Resistoflex trademark.*

RESISTOFLEX CORPORATION, Roseland, N. J.
Western Plant: Burbank, Calif. · Southwestern Plant: Dallas, Tex.

20th year of service to industry

Resistoflex

Fluoroflex-T industrial hose and assemblies are available from leading distributors — write for names.

Circle 497 on page 19

Johnson
Ledaloyl Powder Metallurgy

Bronze or Iron
Bearings . . . Bushings . . . Parts
Offer Many Important Savings

Pre-Lubrication—The porous structure of Johnson Ledaloyl acts as a reservoir for the lubricant, providing sufficient oil during operation . . . storing it when at rest. This feature often eliminates costly lubricating devices and systems, guards against neglect and assures longer operating life of the unit.

Formed to size—The manufacturing process of Johnson Ledaloyl is essentially a forming and sintering operation. This eliminates machining, prevents scrap, yet provides accuracy at a low unit cost. Uniformity of each bearing, or part, cuts assembly time to a minimum. These are but two of the many money-saving features of Johnson Ledaloyl bearings, bushings, and structural parts. Let us show you how to design your product to take full advantage of this economy yet gain greater performance and longer service life. No obligation of course. Write for literature today.

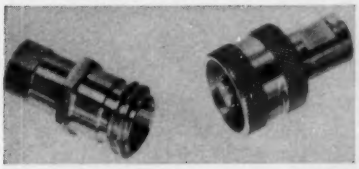
This literature free upon request.

Johnson Bronze

525 South Mill Street • New Castle, Pa.

JOHNSON Bearings

is spring-loaded to prevent loosening through vibration. Seating surfaces fully seal before valves open, eliminating leakage or pos-



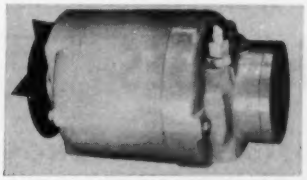
sible frostbite during coupling. Unit is designed to connect with standard POL connectors. Female POL threads and seat in coupling conform to latest CGA standards. **Aeroquip Corp.,** Jackson, Mich.

Circle 694 on page 19

Pump-Motor Combination

is compact and lightweight

Powermite pump and motor combination combines a positive-displacement internal-gear rotary pump, driving motor, and cooling blower in a space measuring 8½ by 4¾ in. A single shaft serves all units. Wide variety of combinations are available for use in hydraulic, lubricating, oil burning and other services involving many



different fluids. Model illustrated has capacity of 18 gph at 300 psi and is driven by a 1/12-hp motor at a speed of 1750 rpm. **Tuthill Pump Co.,** Dept. PR, 939 E. 95th St., Chicago 19, Ill.

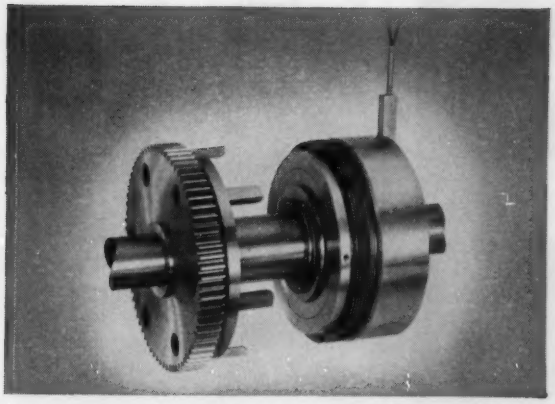
Circle 695 on page 19

Subminiature Relay

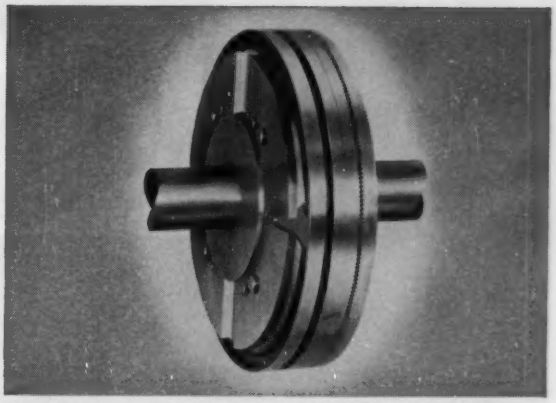
for use on printed circuits

MR subminiature relay, with lug arrangements for use on printed circuits, is designed for easy, rapid assembly. Unit can be adjusted for as low as 10 mw pull-in. It is equipped with brass terminals, with sufficient free length beyond the surface of the terminal board on the relay to facilitate connection

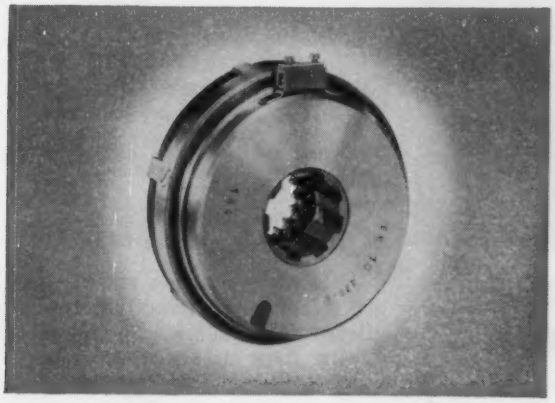
(*Continued on Page* 194)



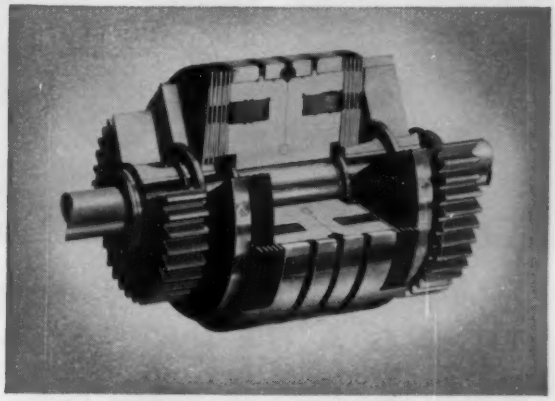
Type R—Stationary field design, showing unit construction.



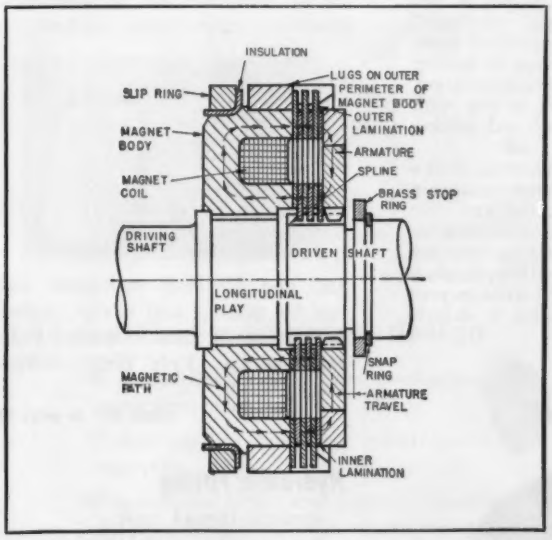
Type F—Serrated face tooth design. High torque, small size.



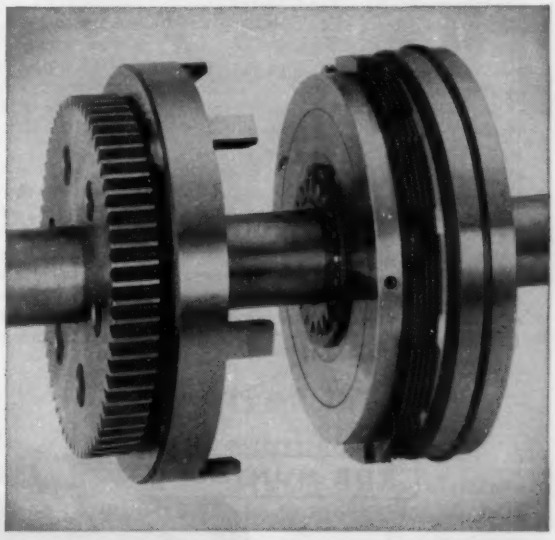
Single clutch equipped on a brake. No slip ring is supplied, but terminal is provided for the coil and user's connections.



Standard double—Gear drive with double Electro Clutch, showing unit construction.



Principle of operation. Alternate laminations key with perimeter lugs and splined shaft respectively. Laminations rotate freely until magnet coil is energized. Magnetic flux compresses the laminations with great force, engaging clutch.



Type C—External drive, showing unit construction.

I-T-E CIRCUIT BREAKER COMPANY • **Transformer and Rectifier Division**

Circle 500 on page 19

New Parts

(*Continued from Page* 191)

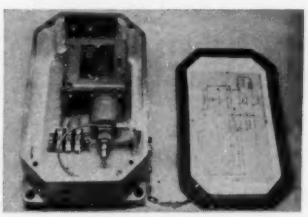
in circuit without interference. Contacts, which give maximum stability of adjustment, permit upwards of 25 w of power control for noninductive applications. Capacity of the contacts for inductive loads is suitably derated. Relay projects slightly less than 1 in. beyond shoulder of printed circuit lugs. **Jaidinger Mfg. Co.**, 1921 W. Hubbard St., Chicago 22, Ill.

Circle 696 on page 19

Lubrication System

stops machinery if lubrication pressure fails

Cyclesafe lubrication system provides automatic protection against lubrication failure. It automatically stops machinery when lubrication pressure drops below predetermined setting. Machinery completes working cycle before stopping, eliminating tool, cutter, die or knife damage or breakage. Electrical connections conform to



JIC and NMTBA standards and can be quickly and easily applied to existing circuits. **Seneca Falls Machine Co.**, Fyfe Bldg., Seneca Falls, N. Y.

Circle 697 on page 19

Hydraulic Fitting

straight-thread unit has metal-to-metal seal

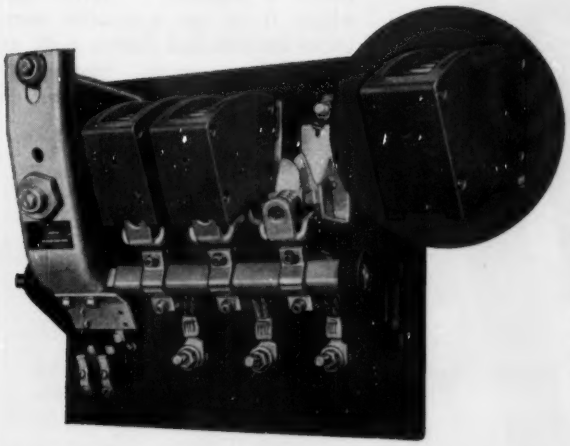
Straight-thread fitting permits positive, leakproof seal through metal-to-metal contact. Space saving is effected in multiple setups where several hydraulic lines must be concentrated, such as in control

for fast arc interruption... without blowout coils

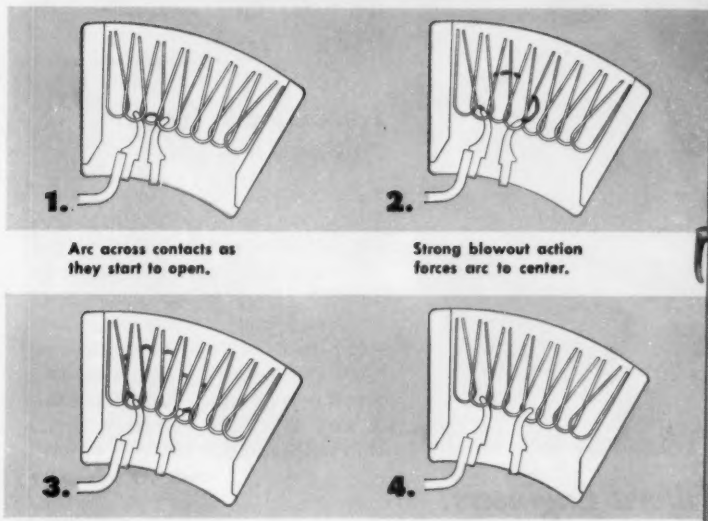
ALLIS-CHALMERS

TYPE 425 CONTROL

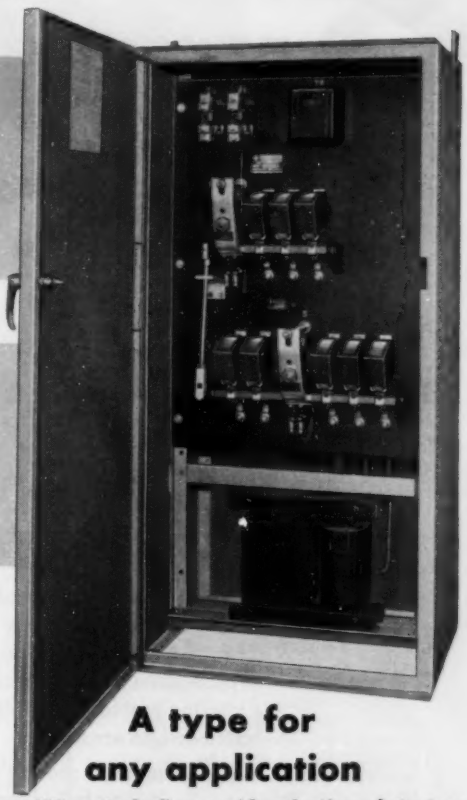
featuring *ACBO* arc-centering blowout chutes for 50 to 400 hp



The advanced electrical design of Allis-Chalmers Size 4, 5 and 6 control incorporates a modern principle of arc interruption for low voltage, high horsepower applications. The *ACBO* arc chute utilizes principles of magnetic action and thermal convection to center, rupture and extinguish the arc . . . quickly. Fast arc interruption assures maximum contactor efficiency, improves performance — greatly prolongs contact and chute life.



1. Arc across contacts as they start to open.
2. Strong blowout action forces arc to center.
3. Arc rupturing.
4. Contacts fully open—arc extinguished.



Simplified mechanical design

- Streamlined clapper-type construction eliminates many parts.
- Accessibility simplifies maintenance and inspection.
- Installation is fast and easy . . . sensible enclosure dimensions provide ample wiring space.

A type for any application

Type 425 control offers a wide selection of starters and contactors for any application. For detailed information, call your A-C Control Distributor or your local A-C District Office . . . or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin. Ask for Bulletin 14B8615.

A-C ALLIS-CHALMERS

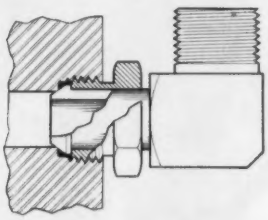
ACBO is an Allis-Chalmers trademark.

ALLIS-CHALMERS

A-5343

New Parts

panels, valves, pumps, cylinders, manifolds and special machinery. Complete flexibility in attaching and removing fitting is achieved with ordinary tools since no swing radius is required. Captive nut, which floats on a smooth stem above its threads, permits body of fitting to remain stationary. Grinding or finishing base or



bosses to obtain tight seal is eliminated. Seal is available in sizes from ¼ to 2 in. OD in all conventional shapes. **Flodar Corp.**, 16911 St. Clair Ave., Cleveland 10, O.

Circle 698 on page 19

Extruded Profile Shapes

are made from Teflon

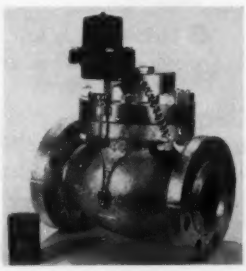
Teflon, now available in extruded-profile shapes, provides toughness and flexiblity and functions well at extremely low temperatures. It is virtually inert to all commercial chemicals and solvents, has zero moisture absorption, good adhesion, heat and weather resistance, and provides long life. **W. S. Shamban & Co.**, 11617 W. Jefferson Blvd., Culver City, Calif.

Circle 699 on page 19

Solenoid Valves

cast-steel units
for liquids to 600 psi

Cast-steel solenoid valves are available in 2, 2½, 3 and 4-in. sizes in either globe or angle pattern with screwed or flanged pipe ends. They



pitch in and ditch...

This Gar Wood-Buckeye 308 Ditcher is designed for really rugged digging. Cross-country pipelining—the toughest gas, water, sewer, conduit and cable lines. Jobs that require day after day after day of high production service. That's why it's equipped with two-speed excavator drive, hydraulic conveyor drive, front drive transmission . . . powered by Chrysler!

CHRYSLER INDUSTRIAL 32

in-line 6 Engine (265 cu. in. displacement) powers Gar Wood-Buckeye Ditchers—and many other makes of equipment in the construction and materials handling field. There are five Chrysler in-line 6s, two V-8s—ranging from 230 to 413 cu. inch displacement. For detailed information about Chrysler Industrial Power write: *Dept. #C4, Industrial Engine Division, Chrysler Corporation, Detroit 31, Mich.*

Chrysler
INDUSTRIAL ENGINES

INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

Circle 504 on page 19

Lightweight, portable tracing unit is only 1 7/16 inches *thin*.

Now you can trace *right at the drawing board*, and save precious minutes with PORTA-TRACE—the thin, lightweight tracing box that *comes to you*.

Simply pick it up . . . place it on your board . . . flick a switch and you're ready —in seconds!

Only 1 1/16 inches deep, PORTA-TRACE can actually be used under the straight edge of your drafting table! Its flush top permits use with drawings larger than unit itself. Plexiglas frame is stainless steel. Available in four sizes up to 24″ x 36″.

Save drafting time and precious space with PORTA-TRACE. Call your local Ozalid representative or write Ozalid, Dept. GG-4, Johnson City, N. Y.

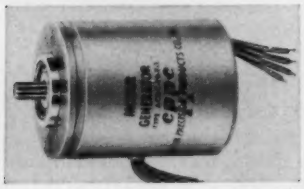
A Division of General Aniline & Film Corporation
In Canada: Hughes Owens Company, Ltd., Montreal

handle liquids to 600 psi. Design incorporates renewable seat rings, unbreakable piston rings and packless operation over a wide pressure range. Coils are waterproof molded for temperatures to 250 F and silicone insulated for higher temperatures. Type EO-2 3-in. valve (shown) is 300# ASA flanged, and is equipped with explosionproof coil housing. **J. D. Gould Co.**, 4707 Massachusetts Ave., Indianapolis, Ind.

Circle 700 on page 19

Motor-Generator

has cast rotor construction



Size 10 ac motor-generator applications include error rate damping in servo systems for high stability. It has cast rotor construction, which offers minimum length and a unit weight of 72 grams. Motor characteristics include: main phase voltage of 26 v, 400 cycles; control-phase voltage, 0 to 26 v; dc resistance per phase of 58 ohms; no-load speed of 7000 rpm; and stall torque of 0.33 oz-in. Generator characteristics include: main phase voltage, 10 v, 400 cycles; output, 0.16 v per 1000 rpm; and dc resistance per phase of 200 ohms. **Clifton Precision Products Co. Inc.**, Marple at Broadway, Clifton Hts., Pa.

Circle 701 on page 19

Wide-Range Microphones

for audible and ultrasonic measurements

Wide-range microphones perform acoustic measurements over both audible and ultrasonic ranges to levels exceeding 200 db. Microphones are stiffness-controlled over specified frequency ranges and introduce no phase-shift errors. High acoustic impedance results in linear response to extremely high magnitudes, so that microphones

(*Continued on Page* 202)

ONE OF A SERIES OF INFORMATIVE MESSAGES FROM HYATT . . .

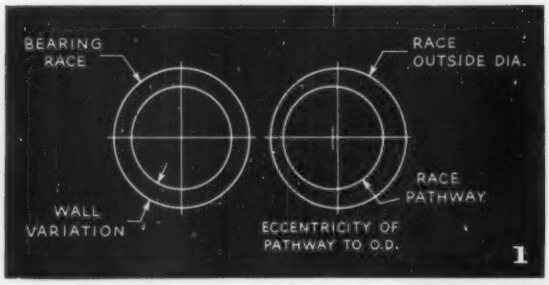
The Inside Secrets of Smoother Performance

How HYATT quality controls assure race concentricity, roller diameter uniformity and other internal essentials of smoother, longer-lived cylindrical roller bearings . . .

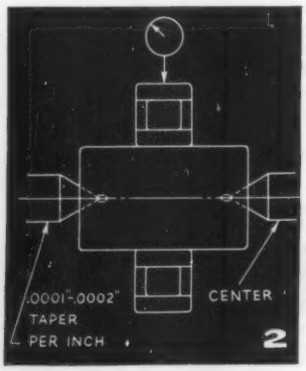
The running accuracy and smoothness of a roller bearing is governed primarily by its internal dimensions and clearances. The most important of these are:

1. CONCENTRICITY OF RACE DIAMETERS

Eccentricity of race diameters is usually interpreted in terms of *wall variation*, Figure 1, on the individual components and in terms of *radial run-out* on the assembled bearing. The



assembled bearing is usually mounted on an arbor, Figure 2, having a slight taper (.0001″ to .0002″ on the diameter per inch of length) and the radial run-out indicated as shown. The radial run-out is the difference between the minimum and maximum readings obtained when rotating the outer race one revolution with the arbor stationary for outer race radial run-out, or rotating the arbor one revolution with the outer race stationary for inner race radial run-out.

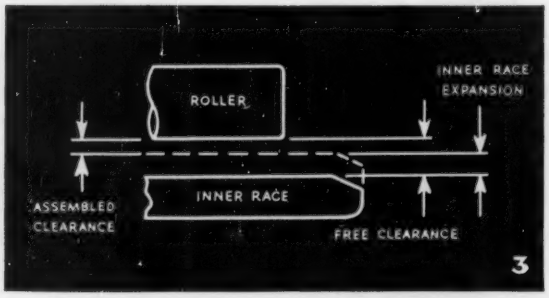


2. UNIFORMITY OF ROLLER DIAMETERS

Another factor governing running smoothness is *roller diameter uniformity*. This is usually obtained by segregating the rollers into diameter variation classes of .00005″, .0001″, or .00015″, depending on the bearing size and the nature of the application, and assembling only rollers of the same group into a given bearing. Gauging for this segregation necessarily rejects excessive taper.

Uniformity of roller diameters is important for another purpose. It provides the user with a bearing in which the internal diametral clearance is controlled within the closest possible limits. The rollers are matched with races which are segregated for pathway size in a fashion similar to the rollers, usually to twice the diameter limits of the rollers. The internal clearance can thus be manipulated at will by combining various diameter classes of races and rollers; but once a particular range is selected, it will remain constant within the combined limits of the roller and race pathway diameter limits. Here, again, a tapered condition of the race pathway is automatically rejected.

Obviously, the internal clearances of commercial bearings must be standardized for the practical reasons of cost and availability, but the clearance values have been so selected that under the specified fits the *running* clearance is at the most desirable minimum, depending on bearing type and size. Figure 3 (magnified).

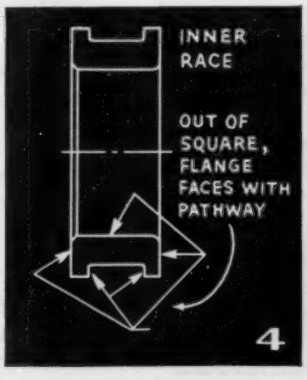


Checking wall variation, flange run-out and race end squareness on combination gauge.

3. SQUARENESS OF ROLLER ENDS AND FLANGE FACES

One other tolerance that contributes to the running efficiency of HYATT Hy-Load Series Bearings of the flanged race type is the *squareness of roller ends with roller diameters* and the *squareness of flange faces with the race pathways.*

Flanged race bearings are commonly used for locating shafts laterally and for running conditions of light and intermittent thrust load. For best operating results, the ends of the rollers must be flat and square with the diameter within a matter of tenths. The lateral clearance between the roller and the race shoulders must also be held to a minimum. This means close tolerances on roller length and race pathway width, and the flange face, Figure 4, must be square with the roller pathway. When all these conditions are satisfied, there will be no tendency for the rollers to skew and raise the operating temperature of the bearing, nor will there be any unusual force on the separator or cage with a tendency toward wracking and noisy operation.



The *side run-out* of the individual races or the *out-of-square* of the ends with the fitting diameters is also important, especially in applications where a number of parts are held together endwise and where the pressure might be sufficient to tilt the race, creating a condition of excessive taper on the roller pathway with consequent roller skewing and the development of excessive heat and noise.

All these internal dimensions and clearances are so carefully controlled that HYATT Hy-Roll Bearings have built an unsurpassed reputation among design engineers for exceptionally long, smooth and trouble-free performance.

YOU WILL FIND MORE DETAILS in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type best suited to your design requirements. Remember, HYATT is America's first and foremost maker of cylindrical roller bearings. Hyatt Bearings Division of General Motors Corporation, Harrison, New Jersey.

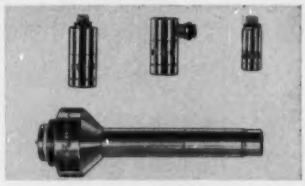
HYATT *HY-ROLL BEARINGS* **FOR MODERN INDUSTRY**

GM GENERAL MOTORS

Circle 507 on page 19

New Parts

(*Continued from Page* 199)



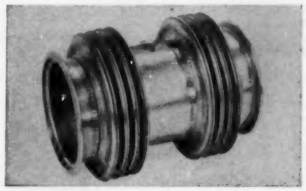
are suitable for measurement of conventional sound pressure levels, blast pressures and shock waves. Units also are well suited for measuring high-frequency sound pressure in exhausts from jet or missiles. Four microphones range in size from ½ to 5½ in. and have frequency ranges from 20-35,000 cps to 20-120,000 cps. **Massa Laboratories Inc.,** 5 Fottler Rd., Hingham, Mass.

Circle 702 on page 19

Titanium Bellows

operate at pressures from 50 to 400 psi

Titanium bellows for aircraft ductwork weigh 44 per cent less than stainless steel counterparts. Bellows are of Rem-Cru A-70 and Rem-Cru A-110AT titanium alloys, which combine high hot



strength and ductile weldability. Sizes from 1 to 3½ in. ID are available. The bellows operate at pressures from 50 to 400 psi. **Titeflex Inc.,** Hendee St., Springfield 4, Mass.

Circle 703 on page 19

Control Components

for industrial machines, processes and systems

Three electromechanical control components are ruggedly designed for use on machines tools, such as tracer lathes, where chip and coolant problems prohibit the use of too delicate devices. Components are: a displacement transducer capable of sensing displacement to

CORNING GLASS BULLETIN

FOR PRODUCT DESIGNERS

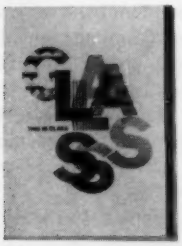
Library of Congress Catalog No. 56-12659

To those learned in the lore of libraries, this simple phrase tells a great deal. It signifies that a book has been received and categorized by the people in Washington.

The volume so designated is "*This is Glass*," a new and completely up-to-date survey of the special glasses and glass products developed by Corning research.

We suspect no usual kind of book club will offer this book as a bonus to its members. But, you can get a copy, free, just by asking us for it.

Here's what the cover looks like.



Why should you want such a book? Because within its 64 pages (sized 8½" x 11" for easy filing) you'll find words, pictures, and tables dealing with glass as a basic material of design and construction.

Sample—pages 12 and 13 tell about the following special types of glasses: Colored, Electrically-Conducting, Multiform, Fiber, Opal, Radiation-Absorbing, Cellular, Radiation-Sensitive, and Optical.

The table on pages 18-19 is devoted to data for 8 *much-in-demand* glasses. It tells of Viscosity Reference Points (working, softening, annealing, and strain); Specific Gravity; Expansion Coefficient; Young's Modulus; Electrical Properties (volume resistivity, dielectric properties); and Refractive Index.

For example, from this table you learn that PYREX brand glass No. 7740, a borosilicate glass, has an expansion coefficient of 32.5 x 10^{-7} per ° C., between 0 and 300° C.

This ability to cope with thermal change, along with immunity to most acids and alkalies, makes 7740 the top choice for diverse applications such as drainlines for waste acids; pipes for corrosive fluids; flasks for coffee (no adding to or taking *from* the taste); heat exchangers; sight glass windows; precision laboratory ware; dental sterilizer trays, humidity chambers—in fact, quite an eye-opening list.

Specifics of this nature are somewhat out of place here, except, we hope as a means of tempting you to expose yourself to the practical and profitable ways in which glass can be used.

"*This is Glass*" is a fine starting point. And it's the type of book that any number of people you know will find both fascinating and useful. Use the coupon.

Heart(h) warming

You're looking at a product that's both warming like a hearth, and heart-warming.

It's Arvin's latest entry in the small, portable put-it-where-you-want electric heater field.

We agree—small electric heaters are not exactly new. But this electric heater uses *glass* as the heating element. That's right, glass—specifically glass by Corning.

These PYREX® radiant heating panels are quite fantastic when you consider that glass normally serves as an excellent *insulator*. But such panels are covered with a permanently bonded, transparent, slightly blue, extremely thin metal oxide coating. It's the coating that carries the dielectric current and puts forth an astoundingly uniform heat.

Permanent and portable heaters are one use to which this glass has been put so far. In other applications it's proven an excellent electrostatic shield.

And turned around with the coating facing a high-heat source it acts as a reflector, bouncing away the unwanted infrared.

As we said—electrically conducting glass can be like a hearth; also heart-warming because here's a material that might just be the answer to some tricky design or engineering problem facing you.

Heavy glass for weighty problems

What can you do with glass that has a density of 6.22, lets you see through, but still is the equal of the same-thickness iron in stopping gamma radiation?

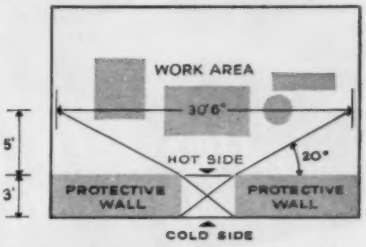
You'll be in good company if you use blocks of this optical-quality glass (along with some other special Corning varieties) to build windows for "hot labs."

These *ponderous peepholes* (that's what LIFE dubbed them) are often constructed with three unusual glasses.

Code 8362 is a nonbrowning lead glass with a density of 3.27 and is practically water-white. 8363 is straw-colored, a really heavy glass, density 6.22. And 8365, weighing in at 2.67 gm./cm.^{3}, is water-white.

In combination (especially as ready-to-install assemblies with oil "baths" between the glass layers) these windows provide protection, plus extremely good visibility.

Glass quality, plus high indices of refraction make for effectively large viewing fields, even with smaller area window on the "cold" side.



Here's a schematic of the field of view provided by a 3-foot thick, standard oil-filled assembly of Corning glass, Code 8362. A number of special glasses by Corning permit visual control plus protection from gamma radiation.

All the facts, including suggestions for radiation shielding window design, are packed into a 12-page Bulletin, PE-51. This recent addition to our literature file is titled "*Corning Radiation Shielding Windows*." One or more copies free with the coupon.

P.S. Glasses for ponderous peepholes are one of many types Corning has developed for special research and industrial problems. If you have a real knotty situation, we may already have a glass answer. Inquire in as much detail as you deem fitting.

Corning means research in Glass

CORNING GLASS WORKS, 52-4 Crystal Street, Corning, N.Y.

Please send me the following material: "This is Glass" ☐; Bulletin B-83, "Properties of Selected Commercial Glasses" ☐; PE-51, "Corning Radiation Shielding Windows" ☐.

Name_____ Title_____

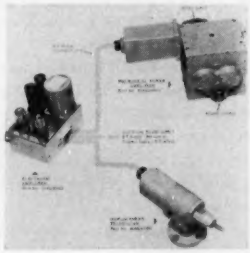
Company_____

Street_____

City_____ Zone____ State_____

New Parts

± 0.0003-in. and supplying a linearly-varying 60-cps electrical signal of 4 mv per 0.001-in. sensitivity; an electronic amplifier for providing power to a standard 60-cps, two-phase servo motor-tachometer from the stylus signal,



and tachometer feedback adjustment for system damping control; and a mechanical power amplifier providing up to 1 hp of control output, using a low-level servo motor-tachometer as input device. **Seneca Falls Machine Co.,** Fyfe Bldg., Seneca Falls, N. Y.

Circle 704 on page 19

Gasketing Materials

of asbestos fiber seal with low bolt pressure

New asbestos-fiber gasketing compounds have excellent flexibility and compressibility. Fibers are refined to eliminate all lumping and bunching, then coated uniformly with rubber binder. In test installations, materials show perfect sealing performance with minimum bolt torque loss at flange temperatures to 500 F and internal liquid pressures to 500 psi. Compounds are available with styrene, nitrile and chloroprene-type rubber binders. **Armstrong Cork Co.,** Industrial Div., Lancaster, Pa.

Circle 705 on page 19

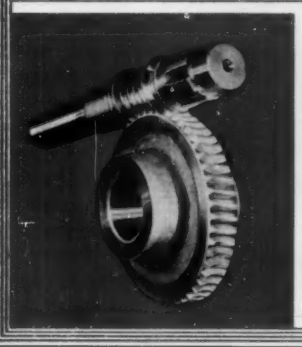
Circuit-Breaking Units

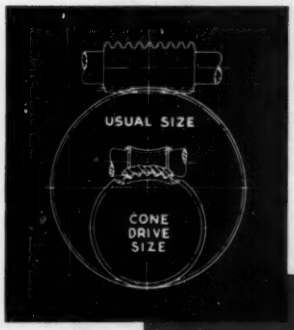
include receptacles, plugs and connectors

Saf-T-Arc Type J receptacles, plugs and connectors provide complete circuit breaking safety. They have deep, insulating chambers, choice of two grounding arrangements, and are polarized so that plugs fit only into receptacles or connectors having the same electrical characteristics. Units have

Circle 510 on page 19

for concentrated power





. . . CONE-DRIVE gearing has no equal.

You can pass an amazing amount of power through a set of Cone-Drive gears.

Want to cut product size? Cone-Drive will give you a more compact gear train with reserve load capacity.

Want to boost power output and hold size? That's easy with Cone-Drive gears. They'll carry two, three, and four times the load of cylindrical worm gearing.

Why? In Cone-Drive gears, the load isn't concentrated on a small area per tooth or on just one or two teeth at a time. Cone-Drive's exclusive double-enveloping principle distributes the load over a lot of teeth and over more area on each tooth.

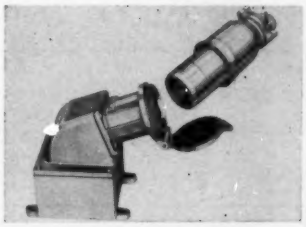
It cuts the unit loading the same way a pair of snowshoes supports a heavy man.

Ask for Bulletin CD-400 for complete details.

CONE-DRIVE GEARS
Division, Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNichols Road • Detroit 12, Michigan

Circle 511 on page 19

New Parts



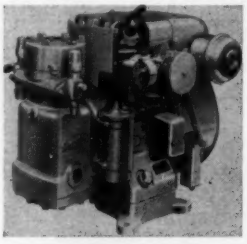
cast aluminum-alloy housings and enclosures, and are available in four complete lines—30, 60, 100 and 200 amp, 600 v ac or 250 v ac or dc. **Russell & Stoll Co. Inc.**, 125 Barclay St., New York 7, N. Y.

Circle 706 on page 19

Engine-Compressors

for cooling applications

Self-powered engine-compressors, available in three sizes with capacities from 1 to 5 tons, are for any cooling application where electric power is not readily available, such as in air-conditioning and refrigeration equipment. Units consist of high-speed refrigeration compressors directly connected to short-stroke, four-cycle, air-cooled engines. The gasoline or propane-burning engine is designed for continuous operation within its horse-



power rating. Electric starter, battery-ignition system and electric choke are for 12-v dc operation. All units are rated at 40 F evaporating temperature and 125 F condensing temperature. **D. W. Onan & Sons Inc.**, University Ave. SE at 25th Ave., Minneapolis, Minn.

Circle 707 on page 19

Power Resistors

in complete range
for MIL-R-26C specification

Resistors, MIL-R-26C type, are available with characteristics G, V or Y and in three basic mounting types: stack mounted, tab

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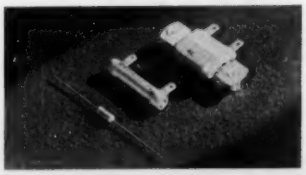
Circle 513 on page 19

New Parts



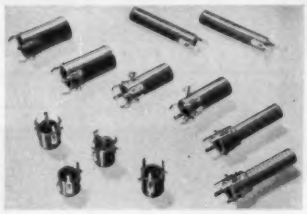
terminal and axial lead. Maximum dissipation ratings are from 2.5 to 210 w. Units are suitable for any application requiring exceptional stability and reliability. **Ward Leonard Electric Co.**, 115 MacQuesten Parkway South, Mount Vernon, N. Y.

Circle 708 on page 19

Coil Forms and Collars

for printed circuits have Berg lugs

New line of printed-circuit coil forms and collars have Berg lugs attached to provide completely reliable soldered joints, and to allow staking to thin or heavy-wall coil forms of varying diameter. Three types of lugs are available, all with standard hot tin finish. Two to six lugs per coil form can be located at any desired angular



configuration. Coil forms and lug collars are available in a full range of ID's, OD's and lengths. **Resinite Corp.**, Div. of Precision Paper Tube Co., Dept. MDC, 6980 N. Central Park Ave., Chicago 45, Lincolnwood, Ill.

Circle 709 on page 19

All-Air Safety Circuit

provides safety for machine operators

All-air safety circuit, consisting of a nontie-down, special - purpose valve, a single-stroke valve and a three-way poppet palm - button valve arrangement, provides safety for operators of presses, brakes, shears and other machines. Cir-

(*Continued on Page* 213)

If you read my "column" you'll really be "in the know"!

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Circle 515 on page 19

Circle 516 on page 19→


GENERAL ELECTRIC ANNOUNCES . . .
NEW Industrial
GENERAL ELECTRIC
DIRECT CURRENT MOTOR

Direct-Current Motor

KINAMATIC* a new standard in direct-current motors, gives your machines wider speed ranges, greater output

To meet modern industrial needs for faster, more automatic, more continuous production, General Electric has designed an entirely new direct-current motor—the d-c Kinamatic.

Designed for Automation—Now, a direct-current motor has been designed for the modern job it has to do—either as individual motor drive or in regulating systems. The new General Electric d-c Kinamatic motor supplies the wide speed range and versatility required for today's manufacturing methods. It is designed for the close control of machines and split-second timing of processes essential to higher output.

Accelerated Production—The new d-c Kinamatic motor will modernize your equipment, give it increased power, higher speeds, greater output capacity. With the quick-acting G-E Kinamatic motor, your machines will process a greater variety of products . . . faster . . . easier . . . and with less maintenance and spoilage.

More Powerful—By combining advanced design with improved materials and manufacturing techniques, General Electric engineers have packed more power into the entire Kinamatic line. The powerful Kinamatic motor, with new stamina and durability, is ready to become one of your most effective weapons for keeping costs down, for meeting competition, for boosting productivity levels.

Engineering Help—Industrial specialists in 149 conveniently located General Electric Apparatus Sales Offices have the complete story on how the new d-c Kinamatic motors and generators can benefit your operation. For full details, contact your G-E Sales Representative, or write for Bulletin GEA-6355. *Direct Current Motor and Generator Department, General Electric Company, Erie, Pennsylvania.* 813-1

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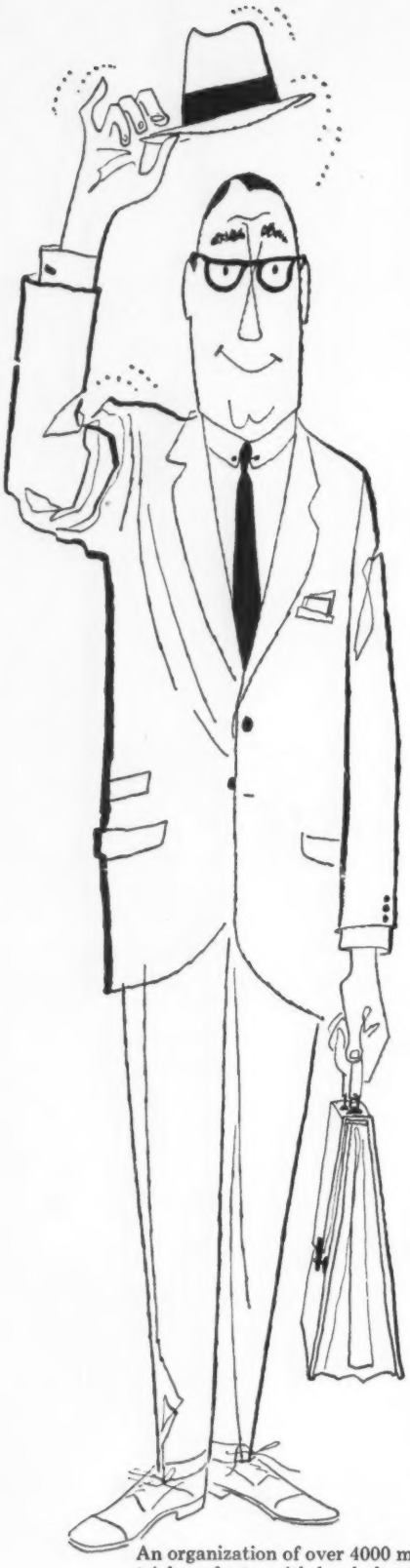
GENERAL ELECTRIC



$21 for a sales call —but how many dollars worth of SELL?

Recent surveys show that the average cost of a sales call is approximately $21. Costs in your company may be somewhat more or somewhat less—but the important question is "How much SELL are you getting for your sales call dollar?"

You are not getting full value unless you are giving industrial advertising a chance to do its proper share of the sales job—making continual contacts, arousing interest, creating preference for your company and its products.

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The salesman always "carries the ball," but he gains more ground when a well-balanced advertising program "runs interference" for him.

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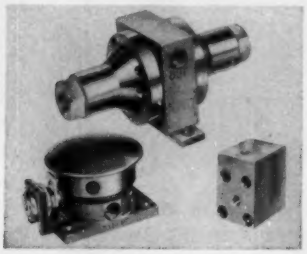
An organization of over 4000 members engaged in the advertising and marketing of industrial products, with local chapters in ALBANY, BALTIMORE, BOSTON, BUFFALO, CHICAGO, CLEVELAND, COLUMBUS, DALLAS-FORT WORTH, DENVER, DETROIT, HAMILTON, ONT., HARTFORD, HOUSTON, INDIANAPOLIS, LOS ANGELES, MILWAUKEE, MINNEAPOLIS-ST. PAUL, MONTREAL, QUE., NEWARK, NEW YORK, PHILADELPHIA, PITTSBURGH, PORTLAND, ROCHESTER, ROCKFORD, ST. LOUIS, SAN FRANCISCO, TORONTO, ONT., YOUNGSTOWN.

(*Continued from Page 208*)

cuit requires two-handed operation to cause a machine cycle. Only one stroke occurs regardless of how long the palm-button valves are held down. Buttons must be released to clear circuit and again depressed to allow another stroke. Malfunctioning of the nontie-down valve due to fatigue failure



or foreign matter automatically causes system to become inoperative. Components can be added to the system to provide emergency stop, continuous, top stop, inching and pneumatic interlock. **Ross Operating Valve Co.**, 120 E. Golden Gate Ave., Detroit, Mich.

Circle 710 on page 19

Mobile Alternator

can be mounted on truck or tractor engines

Electrol GenerAC is a high-output, 60-cycle mobile alternator which produces 3500 w of 115/230-v single-phase power. It starts and operates heavy-duty compressor-type motor loads to 2 hp. Intended as a mobile source of electricity, unit can be mounted on most truck or tractor engines. It is driven through an electric clutch and belt drive which permits alternator to remain idle except when power is needed. **Electric Control Inc.**, Wales. Wis.

Circle 711 on page 19

Illuminated Switch

functions as two switches in one

Dual-purpose, lock-down switch, designated 52PB7-T2, takes the place of an alternate-action pushbutton and also provides optional momentary action. It functions as a conventional pushbutton type when pushed straight down. When

New Parts

pushed and turned about 20 deg clockwise it is maintained in the operated position, and when turned counterclockwise from this position it pops up to unoperated position. Subminiature bulb, independ-

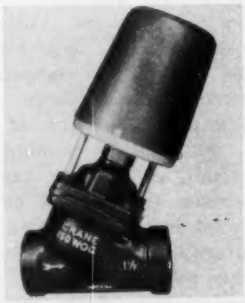
ent of switch circuit, illuminates the translucent button. Two basic switches, actuated by positive over-center snap-action, are available. They are rated 5 amp, 125 or 250 v ac. **Minneapolis-Honeywell Regulator Co.,** Micro Switch Div., Freeport, Ill.

Circle 712 on page 19

Valve Controller

provides remote or automatic valve operation

Valvetrol electric rotary valve controller, designed for mounting on valve stem, provides remote or automatic valve operation with pro-

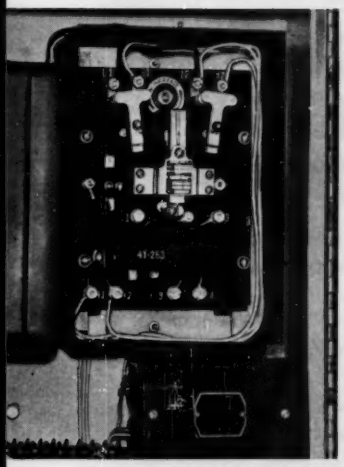


portional or on-off control. Unit is a self-contained gear motor with hollow output shaft that receives valve stem diameters from ¼ to 1 in. Controller incorporates a built-in potentiometer. Standard units provide follow-up accuracies of 0.0004 per cent. Selective gear ratios to the potentiometer adapt controller to valves having from 1/6 to 40 turns to full open. Permanent split-capacitor or three-phase units are available in totally enclosed or explosionproof con-

Another example of how ASCO Solenoid Valves and ASCO Relays solve unusual control problems.

How ASCO CONTROLS sequence rugged car-wash process

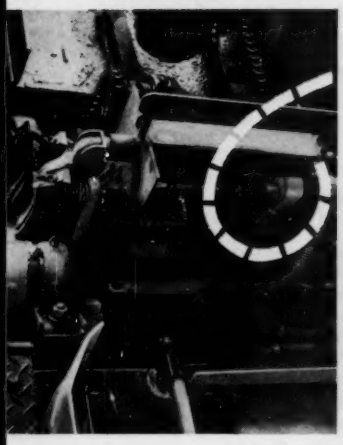
ASCO Solenoid Valves and Time Delay Relay Provide Dependable Control in Adverse Conditions

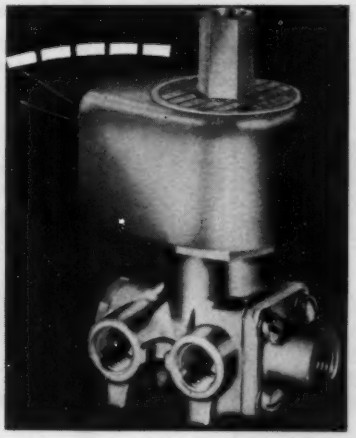


ASCO products have consistently been combined by alert engineers to provide complete automatic control systems. Here is another dramatic example. In the installation shown, Chem-Therm has linked ASCO Solenoid Valves and Time Delay Relay into a soundly engineered and economic package.

Adjusting for different car heights...

The overhead brush in this car-washing process is set for standard models. However, there is an insurance factor in the form of an ASCO Solenoid Valve and Time Delay Relay. Any outsized vehicle or obstruction will close the relay for six seconds. This causes an ASCO 3-way valve, Bulletin 8300, operating in conjunction with a single acting cylinder, to raise the overhead brush for that period of time.





Valving in slush and dirt...

The solenoid valve that controls the tire wheel brushes in this process is exposed to hot water spray and heavy dirt. That is why an ASCO durable midget 4-way valve has been specified. Special watertight molded coils insure continuous operation in the most adverse conditions. Compactness of the valve, Bulletin 8345, and the fact that it can be mounted in any position are design pluses in the close quarters of this installation.

A wide range of ASCO Solenoid Valves and Electromagnetic Control is available to provide top dependability in your sequencing and automated equipment. Write us today about your control problem.

Automatic Switch Co.

54-A Hanover Road, Florham Park, New Jersey

FRontier 7-4600

ASCO®

Circle 520 on page 19

Circle 521 on page 19

New Parts

struction. **Jordan Co. Inc.**, 3235 W. Hampton Ave., Milwaukee 9, Wis.

Circle 713 on page 19

Drive Adapters

are compact and lightweight

New T adapter and reverse-rotation adapter, with housings of aluminum alloy, are compact and lightweight. The T adapter, designed to be utilized where space and weight are factors and where

high speed and heavy torque are required, weighs 8 oz. Reverse-rotation adapter, which weighs 9½ oz., provides for the transfer of power while reversing the direction of rotation of the flexible shaft. Both adapters are furnished with gear ratio of 1:1. **F. W. Stewart Corp.**, 4311 Ravenswood Ave., Chicago 13, Ill.

Circle 714 on page 19

Floated Rate Gyros

operate at temperatures from −54 to 71 C

Floated rate gyros are for use in airborne and control telemetering systems requiring high reliability. Volumetric thermostat controls

temperature to better than 1 C within operating range of −54 to 71 C. Inductive signal pickoff provides high-power signal output. Gyros withstand shock to 100 g, and provide accurate operation

Circle 522 on page 19

NEW Accopac asbestos materials cut gasket costs 15 to 30%

Your asbestos gasketing costs may be cut by as much as 30% with the new Accopac® asbestos materials made by Armstrong.

These new materials are beater-saturated with your choice of synthetic rubbers. They're tough and flexible, won't crack or pipe on bending. They die-cut cleanly. And they seal perfectly at flange pressures as low as 2,000 psi.

Brief specifications on the new Accopac materials are given below. For more detailed information—and samples—write to Armstrong Cork Company, Industrial Division, 7004 Dean St., Lancaster, Pa.

Armstrong Accopac Asbestos Compositions

General Information

Accopac asbestos materials are made by a patented modification of the beater saturation process. Although they are typical Armstrong quality, they're inexpensive because they are made by an exclusive formulation in continuous rolls—literally by the mile.

In the Accopac process, individual fibers are coated with a synthetic latex binder before the sheet is formed. The result is a strong, homogeneous material. Even in very thin gauges, Accopac asbestos sheets are tough and flexible.

Characteristics and Uses

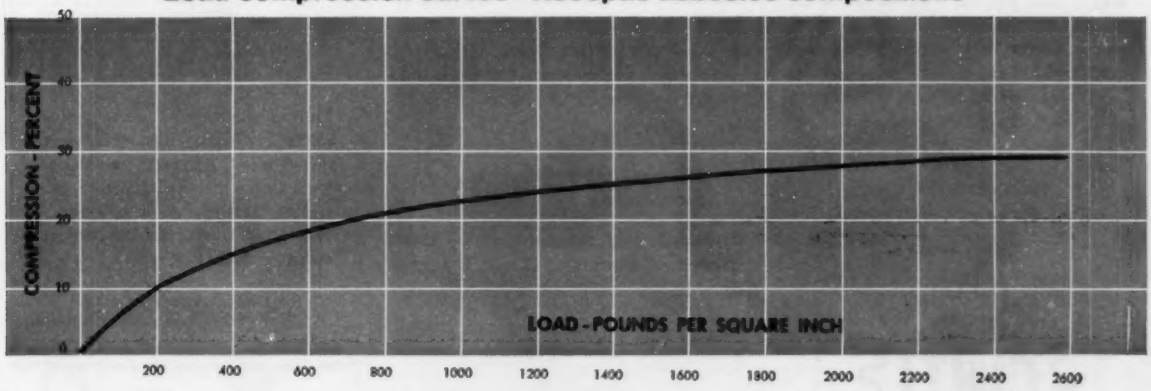
Accopac asbestos materials are recommended for moderate to heavy-duty service. They should be considered for applications where compressed asbestos sheets are now being used.

To provide resistance against a wide variety of oils, solvents, chemicals, and gases, Accopac asbestos sheets are offered with a choice of synthetic latex binders including styrene-type (Buna S), nitrile-type (Buna N) and chloroprene-type (neoprene).

All Accopac asbestos sheets are moderately compressible. They will seal at flange pressures as low as 2,000 psi.

TYPE	BINDER	TENSILE STRENGTH MINIMUM PSI AMD	PER CENT COMPRESSIBILITY
AS-428	Styrene-type rubber (Buna S)	1200	17-27 (1000 psi) 30-40 (5000 psi)
AD-838	Chloroprene-type synthetic rubber (neoprene)	1200	
AN-859	Nitrile-type synthetic rubber (Buna N)	1700	

Load compression curves – Accopac asbestos compositions



You'll find more helpful information on the whole line of Accopac fiber sheet gasket materials in this new folder. Write for your copy today. Address Armstrong Cork Company, Industrial Division, 7004 Dean St., Lancaster, Pa.

Armstrong ACCOPAC

. . . used wherever performance counts

Circle 523 on page 19

New Parts

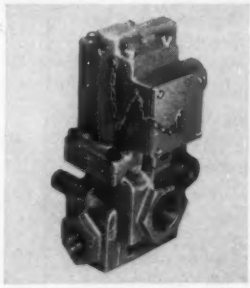
under 25 g vibration over 12 to 2000-cps frequency range. Units meet applicable military specifications. **Norden-Ketay Corp.**, Commerce Rd., Stamford, Conn.

Circle 715 on page 19

Air Valve

is three-way solenoid type

Pilot-operated poppet-type in-line valve meets all JIC standards, including four dust and watertight solenoid enclosures. It has a recessed pin, which can be locked in or out, to operate valve manually without removing the cover. Light-



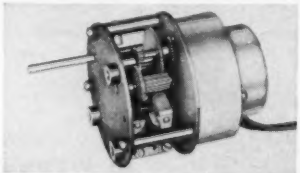
weight aluminum construction and in-line cylinder and inlet ports allow valve to be mounted directly to cylinder. Valve can be used in pairs to control double-acting cylinders. It is furnished in six sizes from ¼ to 1¼ in., either normally open or normally closed with continuous-duty solenoids. **Automatic Valve Co.**, 37415 Grand River Ave., Farmington, Mich.

Circle 716 on page 19

Clutch Motors

for 115-v, 60-cycle applications

Solenoid - operated clutch units consist of standard Circle B motor driving one of the inputs of a dif-



ferential, and a solenoid-operated finger stopping or releasing the other input. Output shaft is disconnected entirely from motor

gear train when not in use, thus full running torque of the motor can be used to start a load. Units provide instantaneous clutching at high speeds, reducing effect of motor lag. Typical applications are in reset and high-speed timers, chart drives, and control applications in which both motor drive and manual setting are required. Motors are available with clockwise or counterclockwise outputs, and with output speeds from 60 rpm to 1 revolution per month. Motors and clutches are rated for 115-v, 60-cycle applications. **Vocaline Co. of America Inc.**, Bristol Motor Div., Old Saybrook, Conn.

Circle 717 on page 19

Coil Heating Unit

withstands temperatures to 1560 F

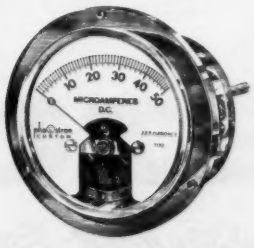
Coil heating unit, sheathed in red Vycor-brand tubing, is suitable for application in portable or mounted heaters, rotisseries, air conditioners, baseboard heaters, and industrial heaters. It is light in weight, easy to clean and electrically safe. Unit is also available in clear glass for use in broiler or hidden elements. It is available in five lengths from 12 to 48 in. and in five wattages from 500 to 2000. Heater withstands operating temperatures to 1560 F. Outside diameter of all lengths of tubing is $\frac{5}{8}$-in. **Corning Glass Works**, Corning, N. Y.

Circle 718 on page 19

Magnet Meter Movement

has excellent sensitivity and high linearity

Core-magnet meter movement has high linearity for 100 deg of scale



arc. Sensitivities as low as 20 mu amp are accomplished with coil re-

(*Continued on Page 222*)

Circle 526 on page 19

STAINLESS STEEL

1/2" O.D. TO

HEAT EXCHANGER, CONDENSER AND EVAPORATOR —Full Range of Sizes

PIPING—Complete Range of Schedules. 40, 10 and 5 Sizes

SANITARY—O.D. and I.D. Polished—For Dairy and Food Processing

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BEVERAGE—Cut Lengths or 50' Coils

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Manufactured at the Steel and Tubes Division, Republic Tubing is welded by the ELECTRUNITE Process . . . a Continuous Electric Weld method that unites the wall under pressure without the addition of foreign or extra metal. Among other advantages this process assures uniformity of wall thickness, strength, ductility, concentricity, diameter and physical and mechanical properties.

Republic, the pioneer in this improved welding technique, is proud of its many "firsts" in the industry. In addition to introducing ELECTRUNITE® Boiler Tubes to the trade more than 25 years ago —plus Electrical Metallic Tubing and Dekoron®-Coated E.M.T. to the electrical industry, Republic was the first to provide a non-destructive electronic production method of testing tubing used for critical pressure applications, known to the trade as FARROWTEST®.

With plants in four locations, we are able to service you promptly with these complete ranges of analyses of carbon and stainless steels for mechanical, structural and pressure uses. A wide selection of sizes for every tube is also available. (See captions.)

Next time you need tubing or electrical raceways, whatever the application, call your nearest Steel and Tube Representative. Or contact us direct. We've solved a lot of problems in 50 years, and we'll be happy to tackle yours. To get descriptive literature, mail coupon at right.

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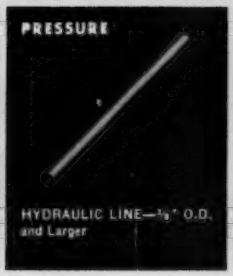
AIR PRE-HEATER—Full Range of Sizes

HYDRAULIC CYLINDER—Up to 3¼" I.D. x .187" Wall—Special Smooth Finish



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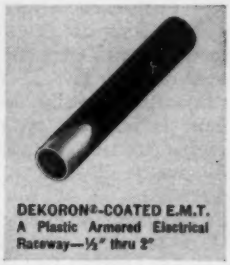
RIGID STEEL CONDUIT—GALVITE®—½" thru 6"



DEKORON®-COATED E.M.T. A Plastic Armored Electrical Raceway—½" thru 2"

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- Electrical Raceways — ☐ Electrical Metallic Tubing
  ☐ Rigid Steel Conduit
  ☐ Dekoron-Coated E.M.T.

Name_____Title_____

Company_____

Address_____

City_____Zone_____State_____

Circle 527 on page 19

New Parts

(*Continued from Page 219*)

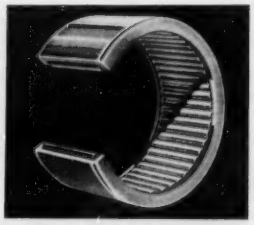
sistance of 3000 ohms. High spring torque provides ample stability. Mechanical design includes sintered rings and pole faces, precision die-cast brackets, and shock-mounted jewel assemblies. Movement is available in 2½-in. round clear-plastic case. **Phaostron Instrument and Electronic Co.**, 151 Pasadena Ave., South Pasadena, Calif.

Circle 719 on page 19

Needle Roller Bearings

use spherical end rollers

Thin-shell needle roller bearings, used in automatic transmissions, employ spherical end rollers to provide maximum capacity and smooth surface contact with the shell.



Shells are of SAE 1010 steel hardened to Rockwell 60 C minimum. Rollers are retained in the shell during shipment by a grease which is readily soluble in automatic transmission oil. Two widths are presently available: 0.500 and 0.625-in., with shaft diameters of 1.0605 and 1.1875-in. respectively. Other sizes will be available for automotive, aviation and general industry use. **Kaydon Engineering Corp.**, McCracken St., Muskegon, Mich.

Circle 720 on page 19

Rectifier Tubes

for high-voltage rectifier circuits

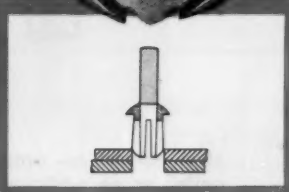
New 6894 and 6895 half-wave, mercury-vapor rectifier tubes are intended for use in high-voltage rectifier circuits designed to supply dc power with good regulation to broadcast transmitters and industrial types of equipment. Both tubes withstand maximum peak inverse anode voltage of 20,000 v. Each delivers maximum peak anode current of 11.5 amp and maximum

Circle 528 on page 19

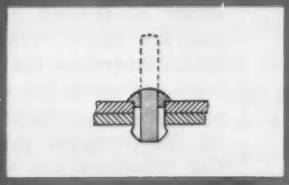
Circle 529 on page 19→

time-saving, neat-appearing **FASTEX®**

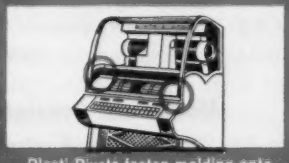
Plasti-Rivets®



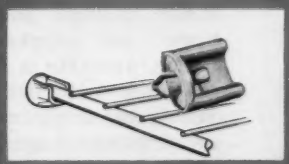
JUST SET . . .



. . . AND DRIVE



Plasti-Rivets fasten molding onto coin-operated machines, are available in colors to complement product color scheme.



The Plasti-Rivet principle has been incorporated in Plasti-Supports (TM); form ideal refrigerator shelf-supports.

Molded of thermoplastics, Plasti-Rivets fasten from one side with a single blow. The prongs expand when the integrally molded pin is driven, providing a positive, vibration resistant lock. Blind assembly is simplified, products improved and time saved while costs are reduced. Plasti-Rivets can withstand a direct shear of up to 500 pounds. Available in a choice of decorator colors and shapes, Plasti-Rivets will never mar or scratch your product's surface. For a firm, positive fastening, specify easy-to-use Fastex Plasti-Rivets.

Write for your free sample packet and informative brochure listing 25 standard Plasti-Rivets. See how simple and economical blind fastening can be.

Fastex Plasti-Rivets Create Assembly Savings in: non-conductive fastening of electrical products, name plate attachments, appliance shelf fastening, rustproof fiberglass awning fastening, and color-matched fastenings for practically any product.

FASTEX / **DIVISION OF ILLINOIS TOOL WORKS**
195 Algonquin Road • Des Plaines, Illinois

In Canada:
SHAKEPROOF-FASTEX
Division of Canada
Illinois Tools, Ltd.
Toronto, Ontario

itw

New Parts

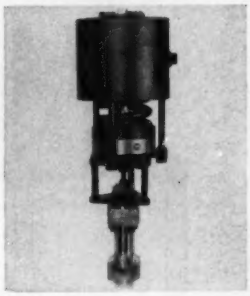
average anode current of 2.5 amp in quadrature operation. Tubes have been designed to resist shock and vibration, and are for use in existing equipment as direct replacements for types 575-A and 673, or in new equipment. **Radio Corp. of America,** Tube Div., Harrison, N. J.

Circle 721 on page 19

Valve Actuators

for pneumatic and hydraulic systems

All-metal actuators for control valves are for use under difficult conditions such as atomic radiation, high temperatures and corrosion. Designed for both pneumatic and hydraulic control systems, the units are available with suit-



able valves as complete control units, or as additions to existing valve installations. Some function either air-to-open or air-to-close and are easily reversible in the field. One model has stainless bellows and stem for use in highly corrosive atmospheres. Small models and those for use in less critical situations are also available. **Robertshaw-Fulton Controls Co.,** Fulton Sylphon Div., Box 400, Knoxville 1, Tenn.

Circle 722 on page 19

Motors and Generators

for servomechanisms

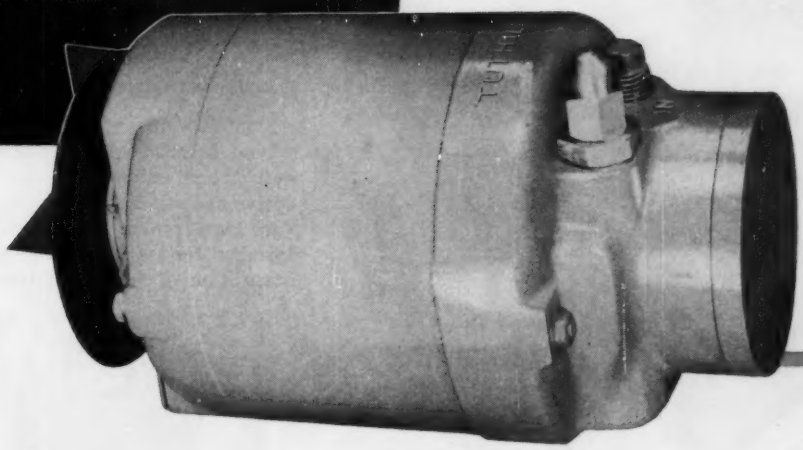
Four new motors and generators are available for precision instrumentation. These are: hysteresis motors, in single and dual speed, single and polyphase; induction motors, available in torque, servo, and other types, with single and dual speed, single and polyphase; ac permanent-magnet generators and tachometers, producing output

ANOTHER PUMP PROBLEM...SOLVED BY **TUTHILL**

new POWERMITE

PUMP and MOTOR COMBINATION

• COMPACT • LIGHTWEIGHT
• ECONOMICAL



Here's another example of Tuthill's ability to develop the pump to fit the problem. This compact, new Powermite motor-pump combination, a Tuthill exclusive, was developed to meet the requirements of original equipment manufacturers with unusual space and weight limitations.

Motor and cooling blower have, in effect, been incorporated into the internal gear positive displacement rotary pump. The whole unit takes up no more space than a standard electric motor. A single shaft serves all units of the Powermite—and the elimination of couplings, other parts and labor permit substantial economies for OEM applications.

The pump section contains a built-in strainer, and, if desired, an adjustable relief valve. Powermite can be furnished with cooling blower, as illustrated, or it may be supplied with a shaft extension for driving other accessories.

Powermite can be furnished in a wide variety of pump and motor combinations for use in hydraulic, oil burning, lubricating, and other services involving many different fluids. For example, the model illustrated has a capacity of 18 gallons per hour at 300 psi, and is driven by a 1/12 hp motor at a speed of 1750 rpm.

Manufacturers desiring to investigate the cost, space and weight saving advantages of incorporating Powermites into their products are invited to submit detailed specifications. Or, if preferred, a Tuthill representative will call.

TUTHILL PUMP COMPANY
953 East 95th Street, Chicago 19, Illinois
Gentlemen:
☐ Please have your representative call to discuss Powermite applications in my product
☐ Please send catalog describing complete Tuthill line.

NAME_____ TITLE_____
COMPANY_____
STREET_____
CITY_____ STATE_____

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities from 1 to 200 GPM, for Pressures to 600 PSI, Speeds to 3600 RPM.

TUTHILL PUMP COMPANY
953 East 95th Street, Chicago 19, Illinois
Canadian Affiliate:
Ingersoll Machine & Tool Company, Ltd., Ingersoll, Ontario, Canada

PUMPS FOR YOUR PURPOSE

Circle 531 on page 19

Circle 532 on page 19

New Parts

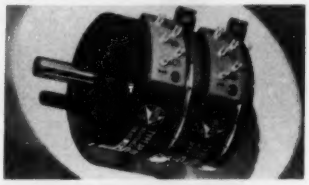
voltage and frequency proportional to speed with a range up to 100 v per 1000 rpm; and sine wave generators with maximum range of 5 v at 1000 rpm, available in single and polyphase units. Motors and generators are offered in base or face-mounting styles. **Syntorque Inc.**, 601 W. 26th St., New York 1, N. Y.

Circle 723 on page 19

Nonlinear Potentiometers

for sine-cosine and square-law functions

Acepot nonlinear, precision wirewound potentiometers in standard and subminiature sizes for sine-cosine and square-law functions assure high resolution and close conformity for such applications as generation of functions, transmis-



sion of angular information, nulling in nonlinear systems, and electromechanical data conversions. Standard sine-cosine units are available in AIA sizes 30 and 20 with tolerances of ±0.5 per cent and ±1.0 per cent peak to peak, respectively. Standard square-law potentiometers are available in the same sizes with tolerances of ±0.25 per cent and ±0.75 per cent independent conformity, respectively. All units meet military specifications. **Ace Electronics Associates Inc.**, 103 Dover St., Somerville 44, Mass.

Circle 724 on page 19

Miniature Clutch

is operated electromagnetically

SF 100 miniature clutch, designed for use on low-torque drive of instruments and miniaturized control mechanisms, is electromagnetically operated. Unit gives instantaneous, positive engagement and release of loads up to 2 lb-in. Axial length is ⅞-in., diameter, 1⅛ in. Flange-mounted field is connected

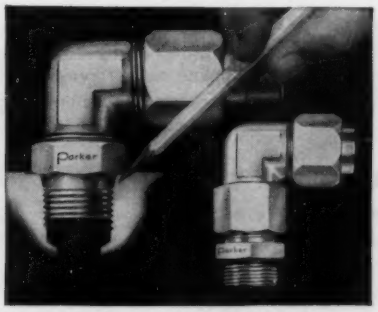
Be sure to see Parker for both tube and hose fittings!

Here, from one convenient source, you can get the most advanced hydraulic fittings available . . . both tube *and* hose. For example, new Parker *no-skive* Hoze-lok fittings require no stripping of rubber-covered hydraulic hose. They're faster, easier to use and *re-usable.*

Also, new Parker *straight-thread* tube fittings solve high-pressure hydraulic leakage problems resulting from tapered pipe threads. *Straight* threads are available on Triple-lok (the industrial standard flare tube fitting) and on Ferulok (flareless fitting for heavy steel tubing).

Parker
Hydraulic and fluid system components

***No-skive* Hoze-lok fittings** need no stripping of hose covers. Only two simple steps complete the make-up. Re-usable.



Straight-thread tube fittings provide leakproof, trouble-free connections. No overtightening. O-ring makes the seal.

TUBE & HOSE FITTINGS DIVISION
Section 422-N
The Parker Appliance Co.
17325 Euclid Ave., Cleveland 12, Ohio

- ☐ Please send *no-skive* Hoze-lok Catalog No. 4433
- ☐ *Triple-lok* Catalog No. 4310
- ☐ *Ferulok* Catalog No. 4320

NAME_____

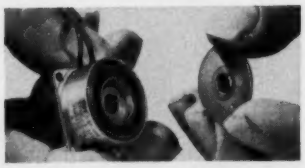
COMPANY_____

ADDRESS_____

CITY_____ STATE_____

Circle 533 on page 19

New Parts



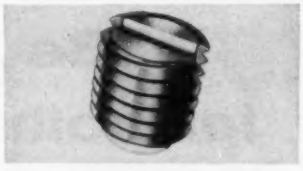
through pigtail leads to 28 or 90-v dc source. Torque is transmitted through the rotor to the armature, which can be keyed to driving or driven member. Power required is 6 w max. Four holes for ⅛-in. capscrews, equally spaced on a 1 5/16-in. bolt circle, are required for mounting. **Warner Electric Brake & Clutch Co.,** Industrial Div., Beloit, Wis.

Circle 725 on page 19

Contact Screw

provides long contact life

New contact screw is a fine silver or silver-alloy core, siver-braze-bonded to a threaded, high-strength alloy shell. Core provides optimum heat tranfer path for dissipation of heat developed by con-



tact arcing. Pitting and wear is greatly reduced, resulting in longer contact life. No oxides can develop between core and outer shell, assuring positive and permanent electrical conductivity between core and shell. Screws are available in all sizes. **George Ulanet Co.,** 413 Market St., Newark, N. J.

Circle 726 on page 19

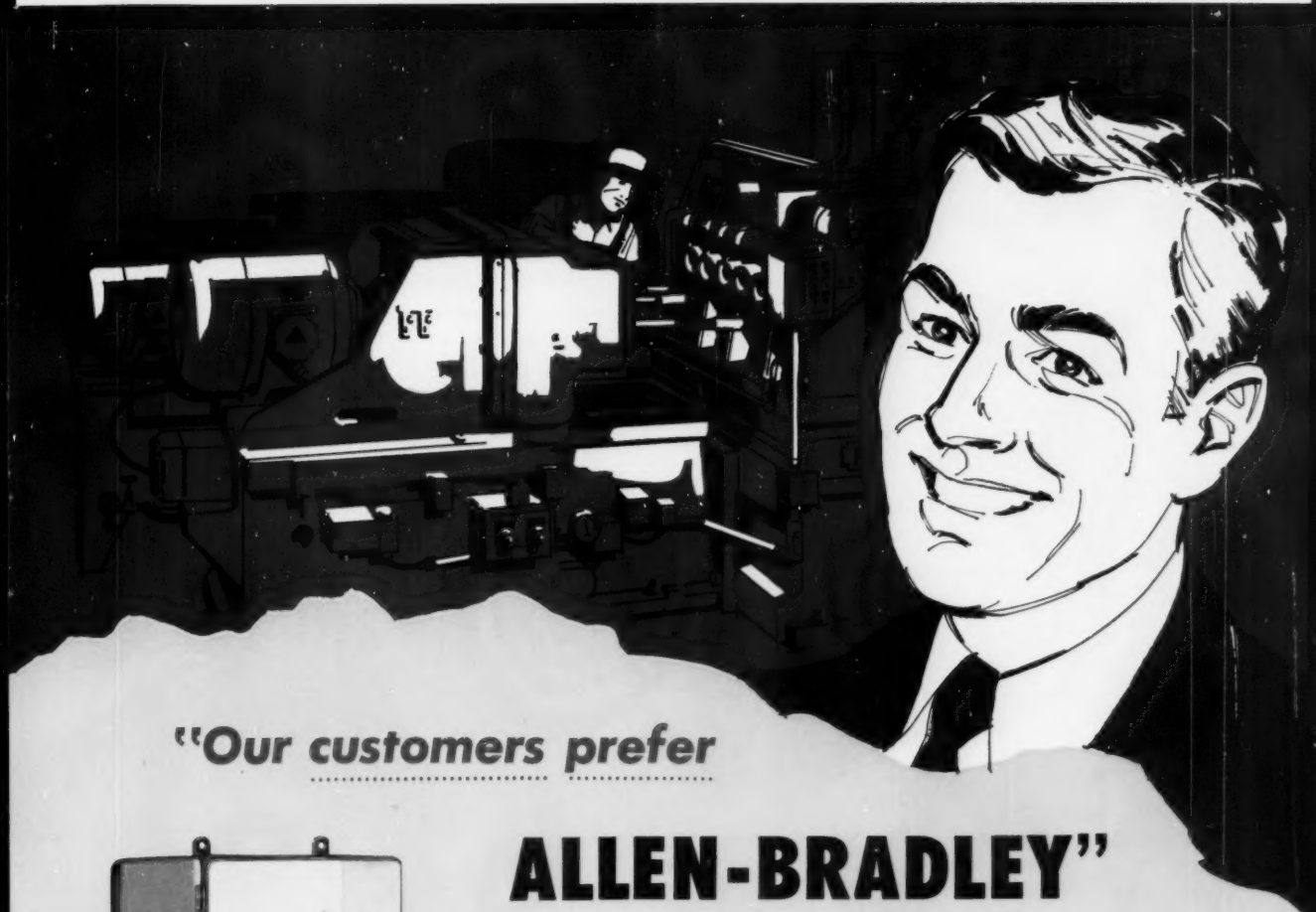
Glass Resistors

for high-temperature use

N and S-style film-type glass resistors have increased resistance ranges from 10 ohm to 4.2 megohm for high-temperature use. They meet requirements of MIL-R-11509B and MIL-R-11804B respectively. S-style resistors operate at temperatures to 200 C and N-style units to 140 C. Both combine high temperature rating, stability and wide variety of re-

Circle 534 on page 19

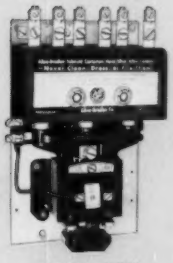
Circle 535 on page 19→



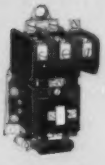
"Our customers prefer ALLEN-BRADLEY"

Bulletin 709
Solenoid Starters—
available in 8 sizes
up to 300 hp, 220 v;
600 hp, 440-550 v.

A-B Quality



Bulletin 702
Solenoid Contactor
Size 3



Bulletin 702
Solenoid Contactor
Size 1

Bulletin 700
Solenoid Relay

Bulletin 800T
Oiltight Push Button

Bulletin 800T
Oiltight Selector Switch

Among leading manufacturers of machine tools, Allen-Bradley Quality motor starters are the favorite—as shown by many independent preference studies. Having the Allen-Bradley Quality trademark appear on your equipment means automatic customer acceptance.

The "simple design" of Allen-Bradley motor control . . . with only *one* moving part . . . guarantees reliable operation. The double break, silver alloy contacts—used in all Allen-Bradley controls—are always in perfect operating condition. Even inspection time—let alone maintenance time—is saved.

No matter what your control requirements may be, they can be met with standard components listed in the Allen-Bradley Handy Catalog . . . Allen-Bradley control specialists can help you with your control problems. *Standardize* on Allen-Bradley Quality motor control . . . add this sales asset to your production machines!

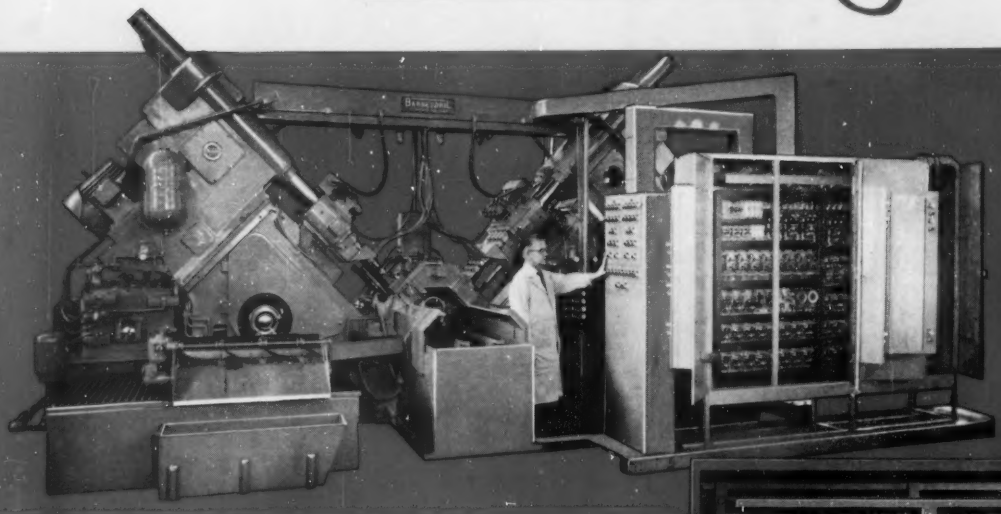
ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

5-57-R

for reliability...plus consistent operation

SPECIFY Allen-Bradley



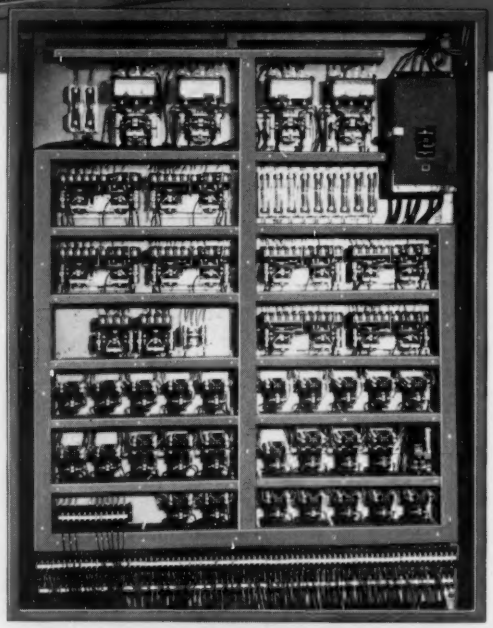
BARNESDRIL
Duplex type honing machine, for honing V-8 motor blocks, equipped with a special Allen-Bradley control panel.

The motor controls on your automatic machines must be reliable when the machines are new . . . and remain reliable when the machines are old. When the sequence of operations is short, the controls must be instantaneous and consistent in their operation . . . or production has to be slowed down to the maximum variation in time of contactor operation. Sluggishness of a single component . . . even for a split second . . . may mean costly repairs and work spoilage.

Reliability is an integral part of all A-B motor controls. The simple solenoid design . . . with only one moving part . . . assures millions of trouble free operations. The double break, silver alloy contacts never need service attention.

Let Allen-Bradley help you with your special control problems. As you know, "quality" and "cheap" are two "teams" never in the same league.

Please send for the new Allen-Bradley Handy Catalog.



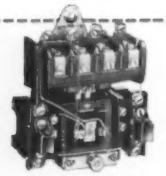
Motor control panel for a Barnesdril honing machine made from standard Allen-Bradley control units listed in the Allen-Bradley Handy Catalog.

5-57-R

A-B Quality

BULLETIN 849
"On-Delay"
Pneumatic Timer

BULLETIN 802T
Adjustable Lever
Oiltight Limit Switch



BULLETIN 709
Automatic
Solenoid Starter

BULLETIN 700
Universal Type
Solenoid Relay

BULLETIN 800T
Oiltight Push Button
Station

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

sistance ranges with high degree of miniaturization. They are recommended for jet aircraft and missiles systems circuitry. Resistors are manufactured by permanently bonding a metallic oxide to Pyrex-brand glass at red heat. Core and film are impervious to moisture. **Corning Glass Works,** Corning, N. Y.

Circle 727 on page 19

Adapter Rings

of phenolic resin and fabric

Phenol-Fab molded hard adapter rings are for use with hydraulic V-ring sets. Phenolic resin and fabric are used in the adapters. When molded at high temperature, they produce a hard, tough com-

position that does not extrude and which reduces scoring of the moving member. Male and female adapters are available in standard cross-sections of ¼, 5/16, ⅜ and ½-in. in standard diameters up to 12 in. OD. **Periflex Inc.,** 111 E. Ten Mile Rd., Hazel Park, Mich.

Circle 728 on page 19

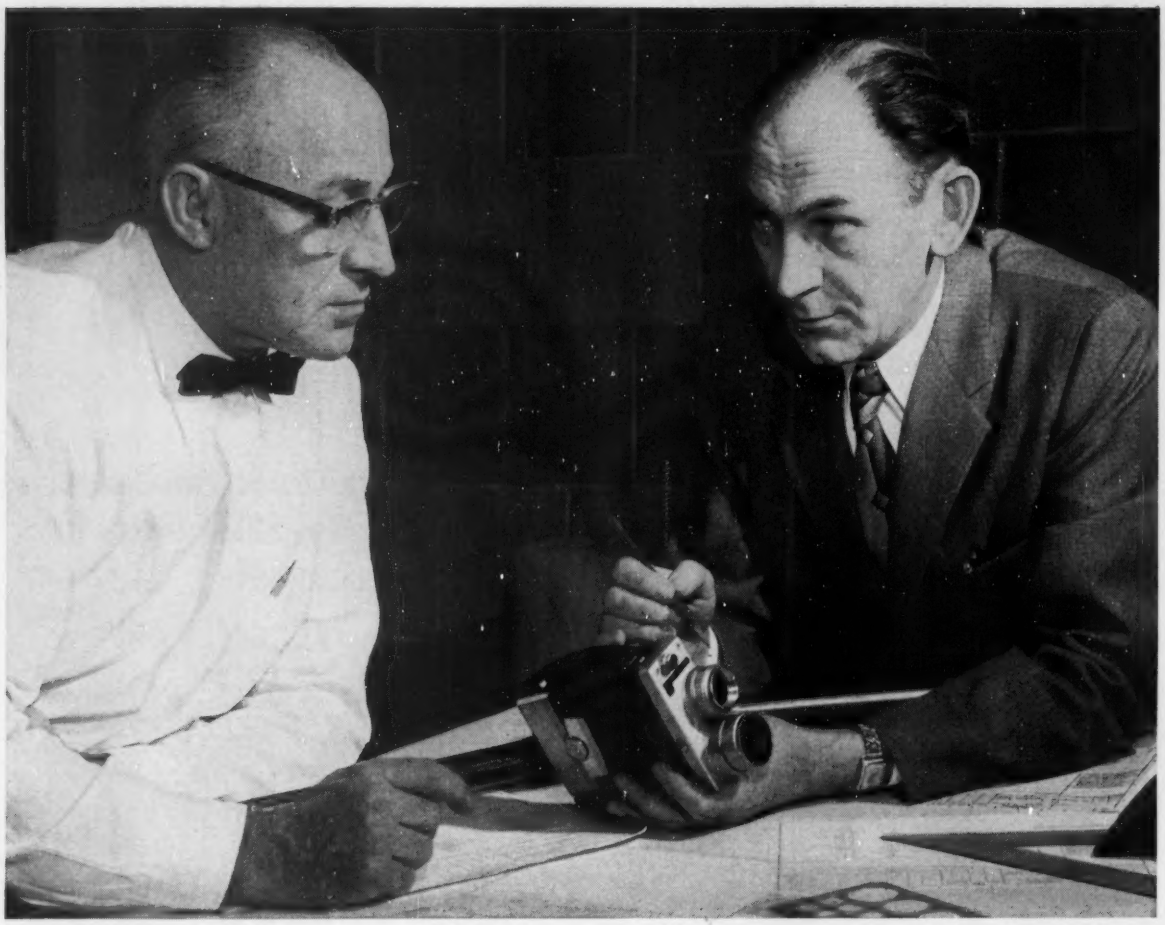
Roller-Gear Drives

for high-speed indexing operations

Series E small, fast roller-gear drives are for the packaging, photographic, pharmaceutical and in-

strumentation fields and other industries requiring high indexing speeds and low torque. Drives are rated for 2000 indexes per minute and minimum of 8000 hr precision

(*Continued on Page* 234)



Essential teamwork between design and production departments calls Oscar Riese, left, Superintendent of Metal Parts Manufacturing, into conference with Chief Engineer Paul Richartz, right.

BELL & HOWELL KEEPS COSTS IN SHARP FOCUS AND USES ALCOA SCREW MACHINE STOCK

Competition is toughest at the top. Nobody knows that better than Bell & Howell, world's largest manufacturer of motion picture equipment. On one hand, there's insistence on precision and fine appearance; on the other, emphasis on cost reduction through faster production.

Dilemma? No, because every time Bell & Howell engineers find a new and faster production technique, Alcoa® Aluminum Screw Machine Stock lives up to its end of the job. A classic example is the lens nose for their Wilshire 8 mm camera. The cycle time for drilling, turning, threading, forming, fluting and engraving this part in one complete operation now takes only 1/50 of the period required originally. Even so, surface finish is held to 32 rms, with other tolerances as tight as .001".

Bell & Howell took a long, hard look at every brass part during the shortages in 1951. They weighed aluminum's advantages—corrosion resistance, excellent machinability, light weight, ready availability and the low cost that comes with three times as many parts per pound. As a result, they're designing first for aluminum and using a whopping 300,000 pounds of Alcoa Screw Machine Stock annually.

To the values that prompted Bell & Howell's decision, add electrical and thermal conductivity. If these considerations prompt an analysis of your own requirements in screw machine stock, you'll find a man who can help at your local Alcoa sales office, listed under "Aluminum" in your phone book. Aluminum Company of America, 873-D Alcoa Building, Pittsburgh 19, Pennsylvania.

Bell & Howell Company

finer products through imagination

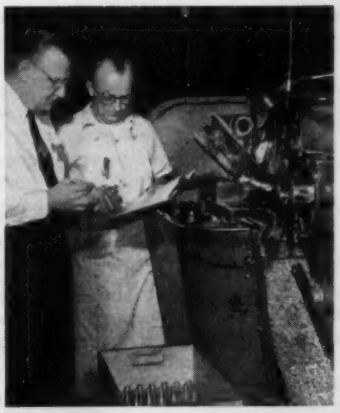
Lens mounts, control knobs, sprockets, film guide rollers and lens caps are among the typical parts machined by Bell & Howell from Alcoa Aluminum Screw Machine Stock.

Purchasing session brings together Chief Metallurgist Arthur Bartmann, left, and Ernest Van Cleave, right, screw machine stock buyer.

IN PURCHASING

"We started with Alcoa and we've always bought from Alcoa. The fact we've never had a reject on their screw machine stock shows that our confidence is well placed. Technical counsel is another advantage. Alcoa helped us assess the relative values of corrosion resistance and machinability to select the alloy best suited to our needs. In the area of deliveries, we've had wonderful cooperation through coordination of shipments with our production schedules. Finally, since heavy stock removal is characteristic of our operations, resale of scrap is an important factor in material cost."

Checking the part (a telephoto lens mount) against the print are John Weber, left, general foreman, and George Sevick, right, operator.



IN ENGINEERING

"Ours is a quality product, depending on a high caliber of precision and appearance for popular appeal. We value aluminum because it lets us design with assurance that the metal will measure up to our requirements and impose no problems in production. We have found that aluminum gives us the high finish and the perfect match from part to part that good appearance demands. We like the versatility that affords us a choice between plating and anodizing. Light weight, achieved with aluminum, is a significant sales point."

IN PRODUCTION

"Concentricity, depth of flutes, diameter of the bore on this lens mount are typical examples of the close tolerances demanded; .001″ is common. Yet, when we find a way to cut production time on a part from more than four minutes down to 49 seconds, aluminum keeps pace with machining speeds. It doesn't punish the tools, so there's less down time for tool changes. And when we're handling 2″ bar stock, its light weight is mighty welcome."

Circle 537 on page 19

New Parts

(*Continued from Page* 231)

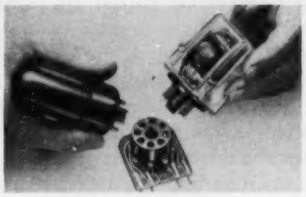
operation. Components consist of a precision-cut, hardened tool-steel cam with tapered rib and hub with standard bearing followers. Units employ a modified trapezoid acceleration characteristic. They are available with 3, 4, 6, 8 and 12 stops, and with indexing periods of 120, 180 and 270 deg. **Ferguson Machine Corp. of Indiana,** Roller Gear Div., P. O. Box 5841, St. Louis 21, Mo.

Circle 729 on page 19

Octal Socket

is incorporated into printed circuits

Right-angle octal socket, suitable for GT-type octal tubes, base relays and coils, is mounted on a laminate base with a printed circuit supplying circuitry to socket and component. Designed for incorporation into printed circuits, socket is held rigidly through sup-



plementary buttress ribs. Base material is 3/32-in. XXXP phenolic (NEMA grade), and copper pattern is 0.0027 on two sides, offering current-carrying capacity of 15 amp per connection. Base material and copper pattern can be altered in size and dimension to meet specifications. Buttress ribs provide structural and mechanical rigidity, resulting in vibration-resistant construction. **Cleveland Metal Specialties Co.,** 1783 E. 21st St., Cleveland 14, O.

Circle 730 on page 19

Air Control Valves

for pressures to 150 psig

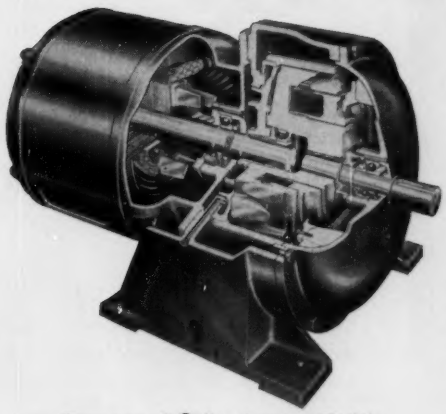
Poppet-type air control valves are available for pressures to 150 psig, for two, three and four-way operation with master (air), single or double-solenoid pilot control. Pipe sizes are from ¼ through ¾-in. Both single and double-solenoid

No Commutators, No Rings, No Brushes, No Rotating Coils—in the NEW

EATON

DYNAMATIC®

Adjustable Speed Drives



Dynaspede® Stationary Field Coupling, with Integral Motor

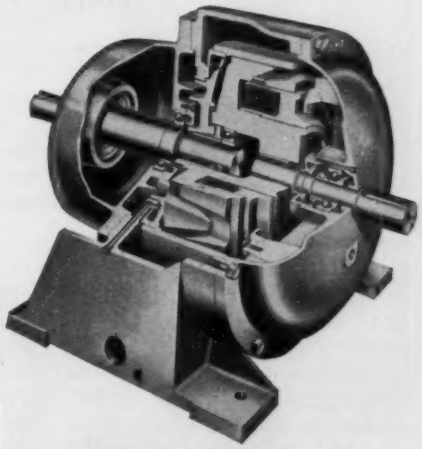
Dynamatic stationary field couplings are the simplest drives so far devised to provide infinitely adjustable speed from an alternating current source. The absence of rotating coils, brushes, slip rings, and commutators in this design holds wear and maintenance to an absolute minimum. Dynamatic electronic or magnetic amplifier controls, in combination with these drives, provide wide latitude in operating functions.

Check these Outstanding Advantages:

Accurate speed control • Wide speed range • Low power losses • Simple construction • Rapid response • Remote control • Quiet, efficient operation • Low maintenance costs

Ajusto-Spede® Drives: Air cooled, stationary field eddy-current couplings mounted integrally with D-flange open drip proof squirrel cage motors are available in capacities from 1 to 75 HP. Units of the same design and capacities are also available without motors.

Dynaspede® Drives: Liquid cooled, stationary field couplings mounted integrally with D-flange squirrel cage motors are available in capacities from 3 to 75 HP. Motor types available are drip proof, splash proof, totally enclosed fan cooled, and explosion proof. The coupling is totally enclosed. Separately mounted couplings are also available in capacities from 3 to 2500 HP and larger.



Stationary Field Coupling for use with Separately Mounted Motor

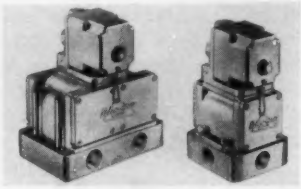
Send for Detailed Information on these New Stationary Field Couplings and Drives

EATON DYNAMATIC DIVISION MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

Circle 539 on page 19

New Parts

pilot heads incorporate unit which provides automatic selection of pilot air pressure supply from whichever port is used as inlet. All three-way valves have two cylin-



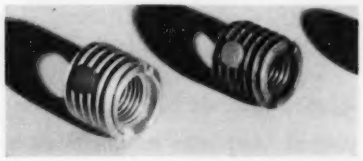
der outlet ports, and four-way valves have side or bottom porting. Pilot heads are completely interchangeable. Models meet JIC pneumatic and electrical standards. All parts are corrosion-resistant. **Galland - Henning Mfg. Co.,** Nopak Div., 2752A S. 31st St., Milwaukee 46, Wis.

Circle 731 on page 19

Threaded Inserts

are self-locking

These self-locking inserts which withstand temperatures from −70 to over 250 F, are now available



down to No. 0 size. Self-locking action is provided on both internal and external threads. Inserts meet torque requirements of AN-N-5, and can be reused without appreciable reduction in torque. **Nylok Corp.,** 611 Industrial Ave., Paramus, N. J.

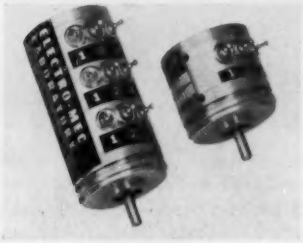
Circle 732 on page 19

Potentiometer

for computer applications

Type 11 low-torque potentiometer for computer use is 1.062 in. in diameter and has synchro-type mounting dimensionally interchangeable with other servo components, motors and resolvers. Metal case provides high degree of mechanical precision and stability. Shaft is mounted in ABEC Class 5 ball bearings, and 18-karat gold

slip rings are used, facilitating operation of potentiometer with a torque of 0.11 oz-in. per cup. Potentiometer is available with any



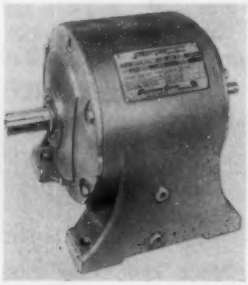
resistance value up to 105,000 ohms, is rated 1 w at 80 C. Toroidal resistor element provides any electrical rotation angle. Standard linearity tolerance is 0.5 per cent. **Electro-Mec Laboratory Inc.**, 47-51 33rd St., Long Island City 1, N. Y.

Circle 733 on page 19

Speed Reducers

have ratings to 50 hp

Strait Line double and triple-redution speed reducers have ratings to 50 hp and efficiency ranges



from 97 per cent or better. Units are available in all models. **Western Gear Corp.**, P. O. Box 182, Lynwood, Calif.

Circle 734 on page 19

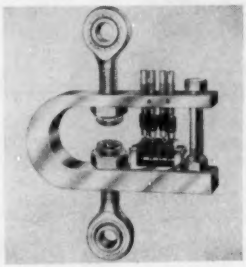
Force-Control Switch

for capacities from 100 to 50,000 lb

Tensile-type force-control switch, Model FCS-T-15, has many applications, including overload protection for hoists and cranes, and operating remote signal and warning devices. It consists of a U-bar with from one to four control switches mounted on one side of

New Parts

open end. On the opposite side finely threaded adjustment screws are provided. Under load, the screws move down and make contact with each switch in succes-



sion or with all instantaneously. Switches are rated at 5 amp for 125 or 250-v operation, at 3 amp for 30-v dc operation. Unit is furnished with overload safety bolt and high-tensile attachment eyes, removable on models up to 10,000-lb capacity. **W. C. Dillon & Co. Inc.**, P. O. Box 3008, Van Nuys, Calif.

Circle 735 on page 19

Cable Tap Connector

speeds connections of shielded cables

Fully insulated one-piece tap connector for shielded or coaxial cable permits savings in installation time. Composed of one-piece com-

bined inner and outer ring and nylon insulation, inner ring of connector slides under shielded braid as tap wire is held between braid and outer ring. Single or multiple taps, either from front or back, can be accommodated. **Burndy Corp.**, Omaton Div., Norwalk, Conn.

Circle 736 on page 19

Relief-Type Fitting

for use on antifriction bearings

RT lubrication fitting is for use on antifriction bearings in motors, machinery, pillow blocks, or any ball or roller-bearing housing equipped with conventional relief

plugs. It has a flip-open cap to speed bearing lubrication. The cap, held tightly in place by spring

tension, snaps open or shut and swivels to any position so that it is easily accessible. Body of the fitting is internally flared to allow free discharge of excess grease. **Keystone Lubricating Co.**, 3100 N. 21st St., Philadelphia 32, Pa.

Circle 737 on page 19

Shut-Off Valve

for high-pressure applications

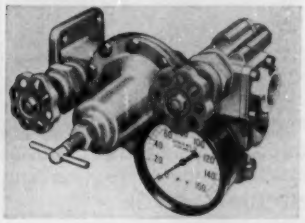
Shear-Seal shut-off valve, rated to 10,000 psi for liquids or gases, withstands surges to 15,000 psi without damage. It has a burst pressure of 40,000 psi. Valve is furnished for pipe, tube or special high-pressure connections. **Barksdale Valves**, 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle 738 on page 19

Air-Control Manifold

for controlling and regulating air pressure

New ½-in. air-control manifold has a cast aluminum body in which are located pressure-reducing reg-



ulator, shut-off valve, strainer, blowdown valve, check valve, pressure gage, and pressure-gage snubber. Subplate mounting permits interchangeability of units. The manifold is useful in applications where air pressure must be regulated and controlled. **Republic Mfg. Co.**, 15655 Brookpark Rd., Cleveland 11, O.

Circle 739 on page 19

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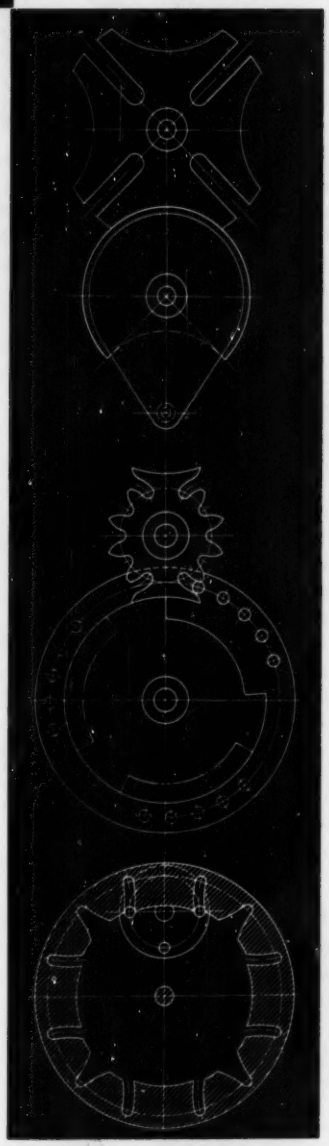

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EQUIPMENT

Oscilloscope

is extremely sensitive

Type 403 oscilloscope provides full-scale amplitude-measuring range of 1 mv to 500 v in 17 steps and is capable of resolving a 20 mu v signal. Frequency response extends from dc to 300 kc. Unit directly reads outputs of strain gages, pressure pickups, accelerometers and other transducers without pre-

amplification. Front panel controls permit selection of 19 linear sweeps from 0.5 seconds per centimeter to 0.5 microseconds per centimeter. Overall accuracy of amplitude measurement on Y-axis is within 5 per cent of full scale. **Allen B. DuMont Laboratories Inc.,** 750 Bloomfield Ave., Clifton, N. J.

Circle 740 on page 19

Time Recorder

for clutch-operated motor-driven units

Load Log records loaded time, in hours or minutes, of motor-driven machines and electrical circuits.

Meter is 4 in. square by 2⅝ in. deep and is projection mounted. Recorder can be supplied in digits

Engineering Equipment

999.9 to 99999.9 in hours or minutes and for 115 v and up and to 25 amp. **Capeway Instrument Corp.**, N. Bedford St., E. Bridgewater, Mass.

Circle 741 on page 19

Recording Oscillograph

has speed selections from 0.5 to 80 ips

Model 561 oscillograph has magazine capacity of 92 ft of recording paper and beam-type interrupter identification. Unit has speed selections from 0.5 to 80 ips, withstands shock accelerations in excess of 1500 g and temperatures from −65 to 165 F. It is suited for aircraft and missile flight test recording and other applications where miniature size and weight are essential. Size is 6 11/32 x 5 3/16 x 9 3/16 in. Power requirements are 28 v dc at 12 amp max. **Midwestern Instruments**, 41st and Sheridan Rd., Tulsa, Okla.

Circle 742 on page 19

Measuring Magnifier

pocket instrument has six-power magnification

Pocket magnifier checks linear dimensions, diameters, radii and angles by direct visual comparison with reticle markings etched on glass. Linear dimensions are given in inches and millimeters. Magnification is 6-power, and instrument is provided with leather case. **Edmund Scientific Co.**, Barrington 21, N. J.

Circle 743 on page 19

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VERTICAL . . . . TILTED . . . . . HORIZONTAL

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Each needle roller is retained in pockets of a cage made of anti-friction, non-ferrous metal. These pockets guide and align the rollers along their entire length. The cage does not wear on the rollers, since the cage land rides on the outer race. Square end rollers provide maximum effective roller length.

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Circle 546 on page 19

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Part Two—discusses physical and electrical characteristics of rotary switches

Part Three—discusses physical and electrical characteristics of push or pull switches

Part Four—discusses factors to be considered when selecting switches from these types for a specific application

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Circle 744 on page 19

Electronic Timer

provides sequences of 1 to 60 seconds

Premier 1310 electronic timer is intended for use on 115 v ac and performs timing operations in photographic use, as well as for technical and industrial applications re-

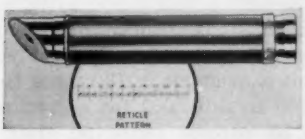
quiring accurate repeat timing. Controls provide timing sequences from 1 to 60 seconds without resetting. Timer includes a focus and time feature for photographic darkroom work, and incorporates an appliance outlet. Unit can be calibrated externally for input voltage differences. Finished in gold hammerloid, it is encased in an ebony phenolic-molded case of high impact strength. **Photo Materials Co.,** 2100 W. Fulton St., Chicago 12, Ill.

Circle 745 on page 19

Pocket Microscope

for measurements to 1/10-in. maximum

This 50-power pocket microscope is suitable for making direct reading measurements and for checking



small parts and dimensions under powerful magnification. It contains a glass-etched reticle cali-

Circle 547 on page 19

Circle 548 on page 19

Engineering Equipment

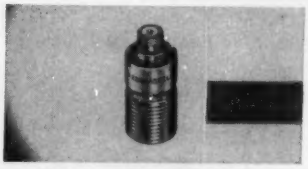
brated for measurements to 1/10-in. by 0.001-in. divisions. Estimates to 0.005-in. can be made. Chrome reflector at base reflects light on object examined or measured. **Edmund Scientific Co.**, Barrington 21, N.J.

Circle 746 on page 19

Subminiature Accelerometer

for measuring vibration and shock

Model 2216 accelerometer, which mounts completely within a ⅜-in. hole, is 0.635-in. high and weighs 8 grams. It provides 5 mv per *g* sensitivity with natural frequency of 50,000 cps. Temperature char-



acteristics are flat ±10 per cent over −30 to 230 F range. Unit is available with adapters for surface mounting on vibration table or device being tested, and matching ⅜-in. tap for mounting within device under test. **Endevco Corp.**, 161 E. California St., Pasadena, Calif.

Circle 747 on page 19

Traction Dynamometer

recording unit is available in 13 ranges to 100,000 lbs

Unit consists of traction dynamometer, two matched synchros and recording case with dial. Load

indication is transmitted to remote station up to 300 ft away. Unit is available in 13 ranges from 0-500 to 0-100,000 lbs. Overloads to 25 percent cause no shift in calibration. **W. C. Dillon & Co. Inc.**, Box 3008, Van Nuys, Calif.

Circle 748 on page 19

THE ENGINEER'S

Library

Recent Books

Mechanisms and Dynamics of Machinery. *By Hamilton Mabie and Fred Ocvirk, associate professors, Cornell University; 442 pages, 6 by 9 in., clothbound; published by John Wiley and Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN; *$8.50 postpaid.*

This treatment of mechanisms and dynamics of machinery features a streamlined coverage of elementary subject matter. As a result, more space is available for the discussion of such topics as analytical cam design, nonstandard gearing, computing mechanisms, synthesis and dynamic analysis of rotating and reciprocating machinery. Many examples are included and a generous selection of problems is offered.

Principles of Electronics and Electronic Systems. *Edited by J. L. Daley, professor, U. S. Naval Academy; 492 pages, 8 by 11 in., clothbound; published by and available from U. S. Naval Institute, Annapolis, Md.; $9.25 per copy.*

This book presents the fundamentals of electronics with the stress placed upon basic theory. The book has two purposes: to serve as a text in electronics at the undergraduate college level, and as a general engineering reference in the field of electronics.

The basic properties of circuit elements, including electron tubes, are treated and the operation of circuits analyzed. Types of equipment are described to show how elementary circuits may be combined to form a complete system to perform a desired function. Generalized systems are treated with operational details omitted and aspects which determine capabilities and limitations emphasized.

Radioisotopes; The Wonder Tool. *Edited by Walter A. Shead; 90 pages, 8 by 10½ in., paperbound; published*

Library

by and available from The Atomic Energy Guideletter, 1420 *New York Ave. N.W., Washington* 5, *D. C.;* $7.50 *per copy.*

In 1956, use of artificially produced radioisotopes resulted in sales by the Atomic Energy Commission of over one million dollars. With the radioisotopes has grown a tremendous instrument industry and a research industry concerned with radioactive labeled compounds and tagged chemicals. This book describes radioisotopes and their by-products; their uses, techniques, applications and sources.

Engineering as a Career. *By Ralph Smith, head of engineering department, San Jose State College;* 365 *pages,* 6 *by* 9 *in., clothbound; published by McGraw-Hill Book Co. Inc.,* 330 *West* 42*nd St., New York* 36, *N. Y.; avalable from* MACHINE DESIGN; $4.75 *postpaid.*

This combination text and problem book is for use in engineering orientation courses. It indicates the qualifications, duties, and responsibilities of engineering and defines the engineering profession in terms of functions as well as branches.

The text emphasizes the functional classification of engineering into the categories of research, development, design, production, construction, operation and maintenance, application and sales, industrial and management. This approach is valuable to the student from the standpoint of career planning. Sufficient technical material is included to enable a prospective engineering student to test his aptitude for and interest in engineering training.

Association Publications

Manual of Consulting and Design Engineering Practices. 20 *pages,* 6 *by* 9 *in., paperbound; published by and available from Michigan Engineering Society, Box* 573, *Kalamazoo, Mich.;* 25c *per copy to members,* 50c *to nonmembers.*

This booklet is the result of national research concerning the kinds and types of consulting engineering services available and about what they cost. The con-

tent includes an outline of engineering services, definitions of services, agreements and scope of services, bases for engineering fees, suggested percentage fee rates, estimating chart, sample agreement forms, and canons of ethics for engineers.

Design of Gray-Iron Castings. *By Arthur Scharf, Battelle Memorial Institute; 45 pages, 6 by 9 in., paperbound; published by and available from Gray Iron Founder's Society Inc., 930 National City—East 6th St. Bldg., Cleveland 14, O.; $1.00 per copy to members, $3.00 to nonmembers.*

This book provides the fundamentals facts and principles for engineering a good design in gray, alloy or nodular cast iron. Contents include designing for function, strength and performance, appearance, and producibility.

Manufacturers' Publications

1957—Silicone Rubber. *45 pages, 8½ by 11 in., paperbound; published by and available from the Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.; $1.00 per copy.*

This booklet reprints three papers given at recent Silicone Rubber Symposiums. The papers discuss the basic chemistry, properties and considerations and compromises involved in compounding silicone rubber for fabrication. The booklet also supplies design engineers with a basic reference for use when considering the material for extreme temperature applications.

Handbook of Mechanical-Spring Design. *84 pages, 8½ by 11 in., paperbound; published by and available on letterhead request from Associated Spring Corp., Wallace Barnes Steel Div., Bristol, Conn.*

This manual contains most of the information the engineer must have to undertake a spring-design project. The book gives the principles of spring design and the fundamental formulas for stress and deflection for every type of spring —compression, extension and torsion helical springs; cantilever and elliptical flat springs; power springs, both motor and hair-

Library

springs; spring washers; and snap rings—as well as for wire forms, assemblies and small stampings. Included is a compilation of the physical and mechanical properties of the most frequently used spring materials along with many practical considerations of spring design and manufacture. For compression, extension and torsion springs, the book also gives the commercial tolerances which can be held under the usual methods of production without extra cost.

Government Publications

Suppression of Body and Hull Noises by Elastically (Floating) Mounted Motors and Engines, PB 121367. *By E. Stolte, Hannover, Germany. 23 pages, 8 by 10½ in., paperbound; translated by Science Translation Service, University of Alabama for Bureau of Ships, USN; available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.; 75c per copy.*

The tendency in contemporary mechanical engineering, according to this report, is toward reducing weight with respect to output by increasing revolutions per minute in an engine. This increase causes intensified engine vibration and noise by resonance of the engine housing. The report describes effective "suppression" of noise and concussion (as distinct from "damping" of vibration) through correct use of rubber-to-metal bonding and with supercritical mountings.

Industrial Preparedness Study of Transistors and Diodes, PB 121291. *402 pages, 8 by 10½ in., paperbound; available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.;* $8.00 *per copy.*

Technical advances in the production of transistors and diodes by the General Electric Co. under contract to the Army Signal Corps between 1952 and 1955 have been compiled in this report. The study gives detailed descriptions of methods for processing of germanium and manufacturing techniques for junction rectifiers, point contact transistors, and germanium high-current rectifiers.

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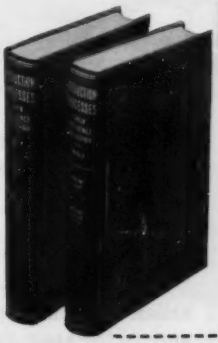

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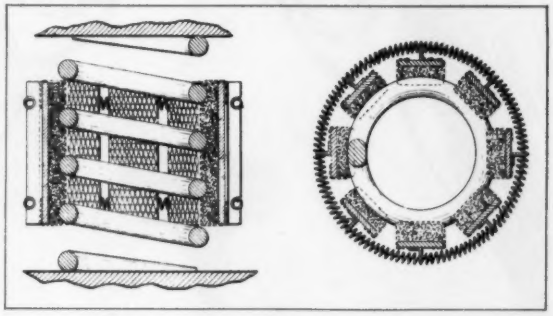
NOTEWORTHY

Patents

Spring Damper

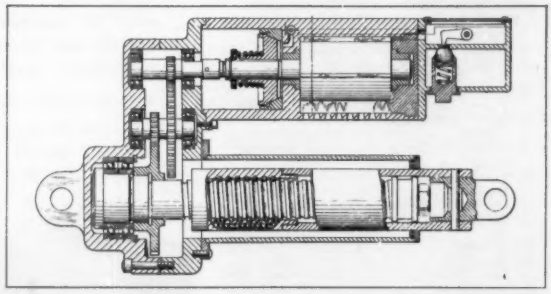
Vibration harmonics of helical springs are suppressed by circumferentially spaced friction elements in a damping device for load-supporting springs. Friction elements, which are compressed against the



load spring helices by encircling garter springs, are compacted woven-wire mesh. *Patent* 2,775,445 *assigned to Metal Textile Corp. by Alfred M. Goodloe.*

Pneumatic Actuator

Designed for operation by high-temperature gases (to 900 F), a linear actuator comprises a reversible pneumatic motor, gear train, extensible ball-screw mechanism and automatic brake. Application of air pressure to the unit releases the brake, permitting precise translation of the screw in either direction. Release of pressure automatically locks the brake,



stopping coast or overshoot. Unit can be operated in environmental temperatures to 600 F. *Patent* 2,778,344 *assigned to Thompson Products Inc. by William A. Compton, James W. Johnson and Robert A. Paetz.*

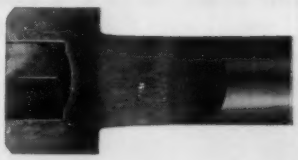
Ball-Detent Mechanism

Rotation of the control knob of a ball-detent mechanism is blocked until the operator applies axial pressure to the knob, releasing the spring-loaded ball from one of its restraining notches. Rotation of the con-

The BUY word for Socket Cap Screws is ALLEN

The *easy* way to make sure of greater strength, better fit and uniform quality in socket cap screws is to order "not just Allen-type but genuine ALLEN."

PRESSUR-FORMING



The latest improvement in the cold forging method originated by Allen. The tough Allenoy steel fibers are preserved continuous and uncut.

GRIP HEAD CAP SCREWS
The world's easiest starting, straightest driving, firmest holding cap screws.

FLAT HEAD CAP SCREWS
For firm fastening with flush surfaces. Especially adapted to fastening thin plates and sheets.

BUTTON HEAD CAP SCREWS
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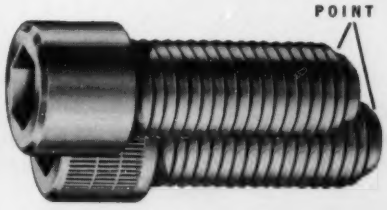

Bright, non-corroding high tensile strength type 18-8. 151 popular sizes (NC & NF) with Smooth Heads *available from stock*. Also standard with Grip Heads in many popular sizes.

THE ALLENUT

Provides a ready-made threaded hole for use with cap screws in soft materials and for repair applications. Endless uses for compact design, space saving.

Sold Only Through Leading Industrial Distributors

Take advantage of their large stocks and fastener experience. Write direct for General Catalog G55.

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MANUFACTURING COMPANY
Hartford 2, Connecticut, U.S.A.

ALLEN HEAD

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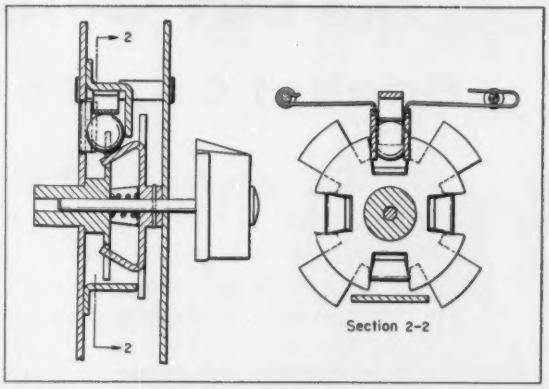
Circle 555 on page 19

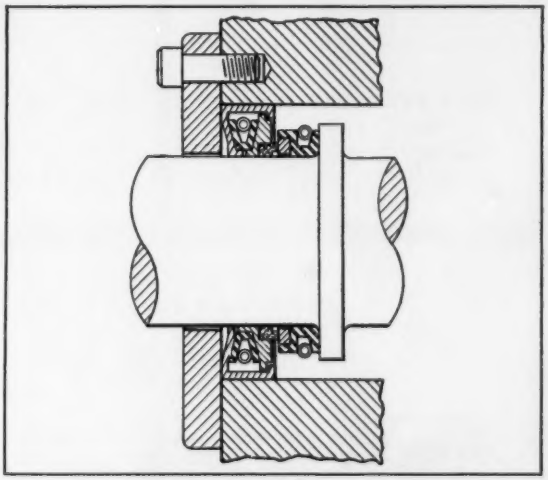
Noteworthy Patents



trol knob (without continued axial pressure) then moves the co-axial output shaft of the unit to its next indexed position. Typical application is for positive positioning of switch elements in electronic components. *Patent* 2,778,229 *assigned to General Electric Co. Ltd. by Arthur Ian Forbes Simpson, Leamington Spa and Arthur Warrington.*

Shaft Seal

Self-aligning and self-adjusting for wear, a fluid seal provides effective sealing between a rotating shaft and a housing at high oil pressures and at either high or low fluid viscosities. Contact between face-



type sealing elements, comprising mating Teflon and hardened-steel annular rings, is maintained by encircling garter springs. *Patent* 2,752,177 *assigned to Anco Inc. by Robert Stevenson.*

Self-Countersinking Screw

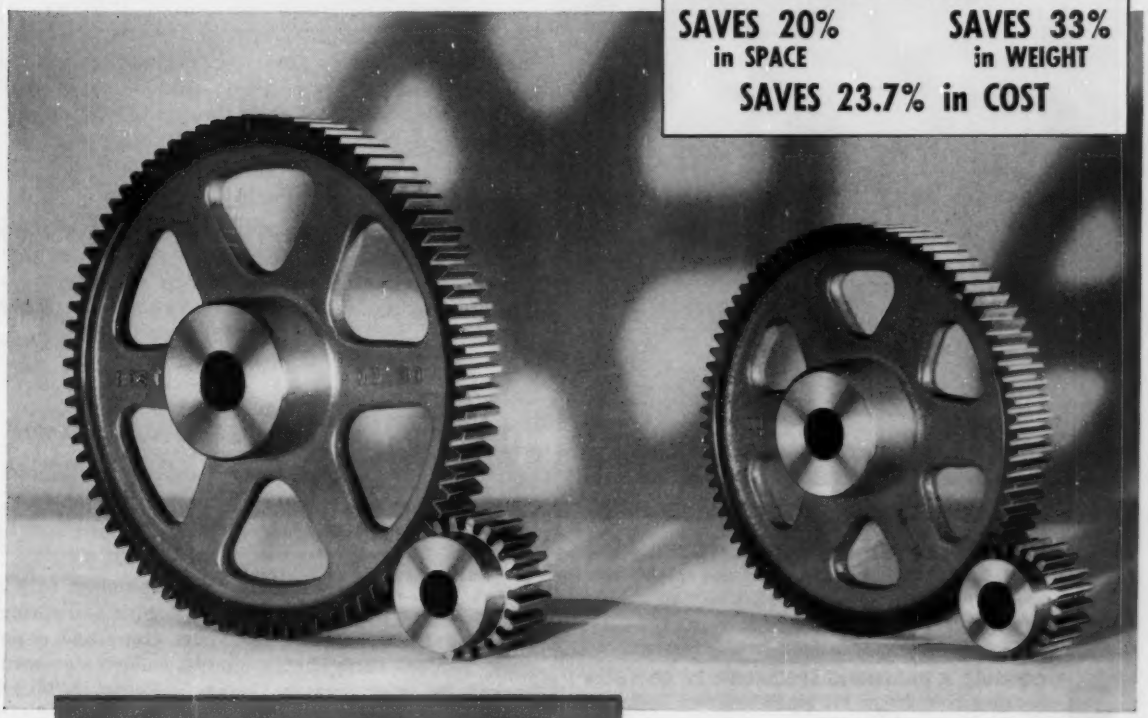
Material fibers are compressed in both axial and radial directions by the driving action of a self-countersinking screw. Shearing of fibers by cutting-slot edges releases fiber compression and causes sheared-off chips to explode out of the driving slot. Clogging of the screw hole, with resultant screw breakage, is therefore prevented. Unrelieved cutting

They both meet the job specifications . . . but one of these gear sets costs you 23% less

20° PRESSURE ANGLE		COMPARE SAME RATIO	14½° PRESSURE ANGLE	
Pinion	Gear		Pinion	Gear
2"	8"	Pitch Diam.	2.5"	10"
5"		Center Distance	6.25"	
1 lb. 3 oz.	9 lb. 1 oz.	Weight	2 lb. 3 oz.	13 lb. 2 oz.
3.67	14.60	Price	4.72	19.20

SAVES 20% in SPACE **SAVES 33% in WEIGHT**

SAVES 23.7% in COST



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441 STANDARD SIZES *From Stock!*

SPUR
Steel and Iron
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Fine Pitch Brass
64, 48, 32
and 24 P.

MITER
Cast Iron
8 to 2½ P.
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Fine Pitch Brass
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and 24 P.

BEVEL
Steel and Iron
20 to 3 P.
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Every engineer knows the quiet-running efficiency and high strength of the 20° Pressure Angle tooth form. For most installations, the 20° P. A. Gear that meets specifications saves an average of 20% in space, weight, and cost over the comparable 14½° P. A. Gear required.

Now, the types and sizes of 20° P. A. Gears you need to make these big savings in your assemblies are *available, anywhere in industrial U. S. A. or Canada,* FROM STOCK at BOSTON GEAR Distributors.

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BOSTON Gear DISTRIBUTOR

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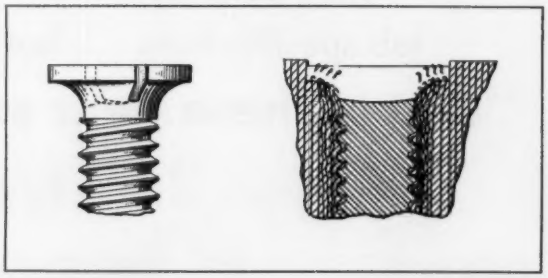
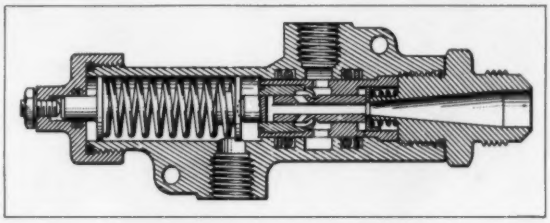
Noteworthy Patents



edges prevent screw from backing out under the influence of vibration. *Patent* 2,764,053 *assigned to General American Transportation Co. by Louis J. Lovisek.*

Flow-Compensated Reducing Valve

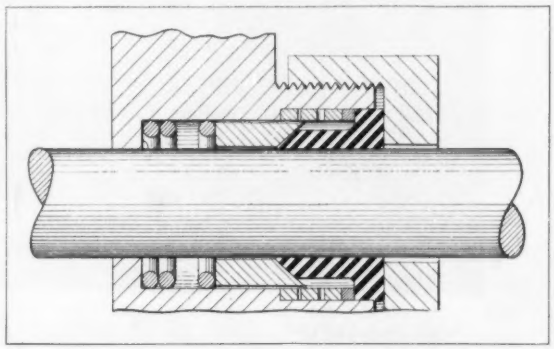
Momentum force variations accompanying changes in fluid-flow rate are compensated by inclined flow passages in the shuttle of a pressure-reducing valve. Result is to hold regulated pressures at the outlet



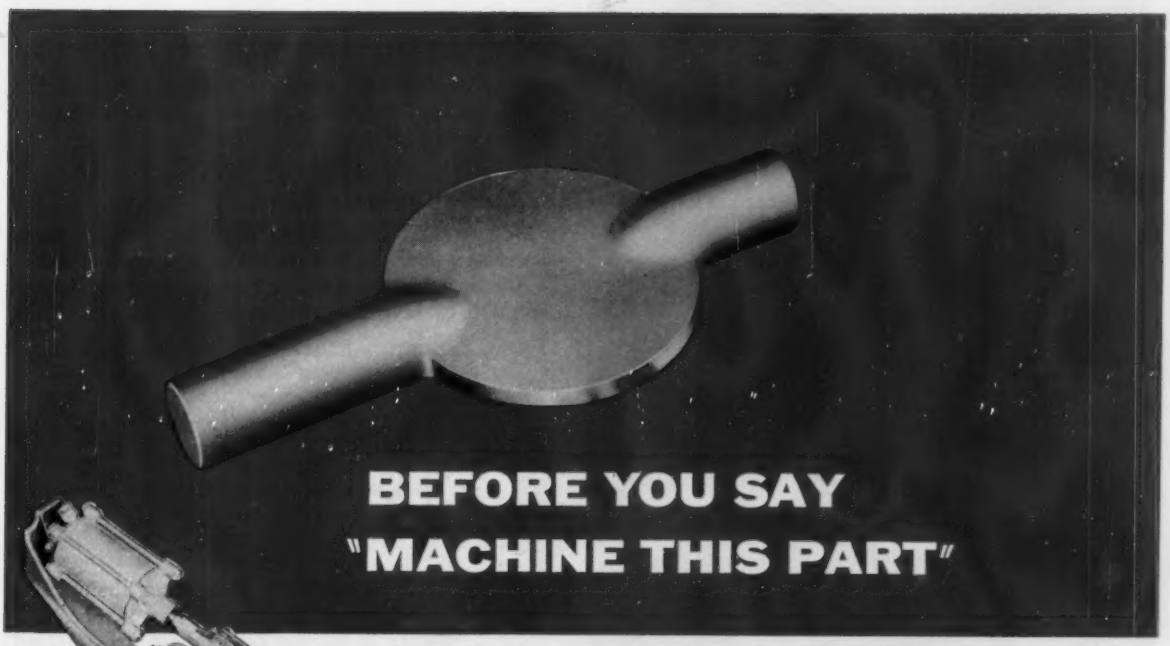
port (right) to substantially constant values over a wide range of volume flow rates. Dashpot and spring, positioned between valve inlet port (top) and outlet port, cushions valve shuttle against sudden movement caused by inlet pressure surges. *Patent* 2,755,815 *assigned to Bendix Aviation Corp. by Donald Zaner Erle.*

Shaft Seal

Fluid or gas leakage between a housing and reciprocating or rotating shafts is blocked by a Teflon sealing element in an adjustable mechanical shaft



seal. Resistant to high temperatures and corrosive media, the Teflon sleeve is spring loaded to permit external adjustment for wear and to provide desired sealing pressures. Low friction coefficient ensures

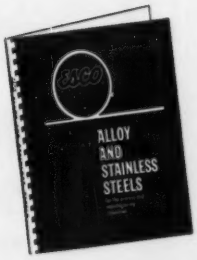


Call an ESCO Casting Engineer

It's often the seemingly simple parts that cause the production "headaches". In this case the "butterfly"—the simple disk and shaft assembly in an exhaust gas actuated power brake. These small parts presented complicated machining and fabricating operations. The elliptical shape of the disk, the compound bevel of the disk edges, the slotting of short length of shafting, welding the shafting in perfect center and alignment on the disk and finally the turning of the shaft ends or bearings. All this fabrication had to be done in a heat-resistant steel to eliminate warpage of the disk, because the blow-by of exhaust gases would result in decreased operational efficiency of the power brake unit.

Oftentimes the answer to such a problem can be as simple as this one was.

. . . "Shellcast this part". And the result . . . a one piece casting combining the elliptical beveled disk with an integral shaft. Cast so smooth and to such close tolerances that the only machining operation to be performed was the bearing ends of the shaft. Heat resistant *ESCO* Alloy 43H, (A297-55 Grade HH) also eliminated the warpage problem at the same time.



Whether you make butterfly valves, or any one of a million or more complicated components of either low or high alloy steels, before you say "machine this part" call an *ESCO* Casting Engineer.

Write for *ESCO* booklets No. 175 and No. 205.

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Offices in Most Principal Cities
ESCO INTERNATIONAL, NEW YORK, N. Y.
IN CANADA ESCO LIMITED

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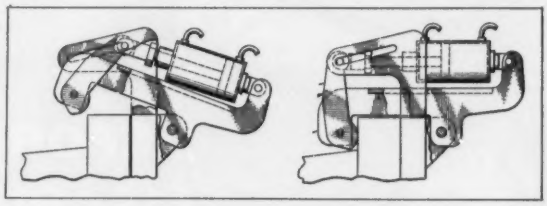
Circle 559 on page 19

Noteworthy Patents

positive sealing with minimum friction torque on the shaft. *Patent 2,745,687 assigned to Crane Packing Co. by Theodore T. Stack.*

Automatic Clamping Device

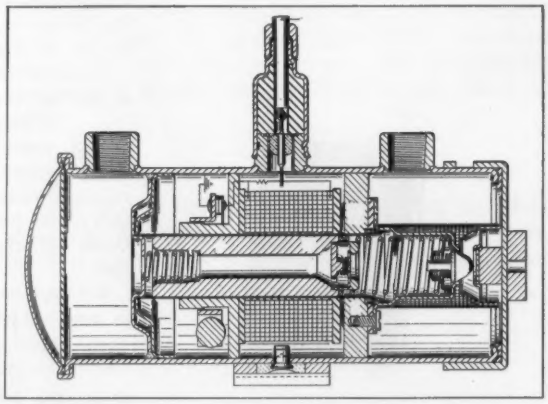
Flanged parting surfaces—for example, on pressure-vessel doors or lids—are firmly pressed together by the cam action of an automatic clamping device. Actuated by a hydraulic cylinder, the unit combines



a rocking, pivoting motion in going from the open or unclamped position (left) to the clamped position (right). Clamp is opened and flanges are released when hydraulic pressure is applied to the opposite side of the cylinder. *Patent 2,776,854 assigned to Fletcher Aviation Corp. by Victor J. Billstrom.*

Electromagnetic Piston Pump

Fluid-transfer path in an electromagnetically operated reciprocating pump is from the inlet chamber (right), through a check valve and hollow piston, to the outlet chamber (left). Battery-operated solenoid,



which alternates with an axial spring in forcing the piston to reciprocate, also actuates the pump check valve. *Patent 2,765,747 assigned to Bendix Aviation Corp. by Kenneth Donald Aumick.*

Porous metal plugs bring lubricant by capillary action from an internal reservoir to the wear surface of a self-lubricating machine element. Distribution of lubricant over the wear surface, which is a dense, nonporous, bearing-quality material, is facilitated by grooves pressed into the surface. *Patent 2,752,211 assigned to Allied Products Corp. by John Haller.*

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"MONOBALL" Self-Aligning Bearings

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CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Moly Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. Address Dept. MD-57

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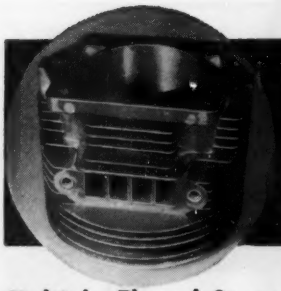

TAP-LOK® INSERTS

Multiply Thread Strength in Soft Materials

Tap-Lok Inserts provide increased thread strength in this aluminum casting—a cylinder for a 2-cycle engine. Two Inserts are shown plainly above, installed in the casting. Three others are on the opposite side of the cylinder

Tap-Lok Inserts are threaded bushings of steel or brass for use in relatively soft metals, plastics and other materials. Self-tapping and friction-locking in a single operation, they eliminate the need for separate hole preparation or secondary operations.

Designed primarily for original equipment installation, they are also excellent for salvage and thread repair.

Write for additional information.

Also manufacturers of Groov-Pins for positive locking press fit.

U. S. Patent 2,455,580
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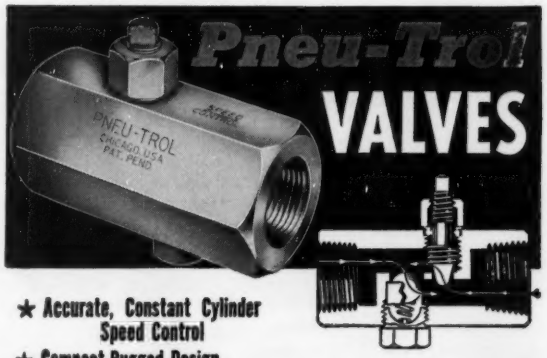
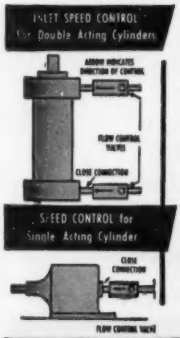


★ **Accurate, Constant Cylinder Speed Control**
★ **Compact Rugged Design**
★ **Simple, Easy Speed Selection** ★ **For Air, Oil or Water Applications**



Pneu-Trol Speed Control Valves, are widely used in hundreds of control applications because they combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to its seat, requiring only a slight differential pressure to fully open or close it.

Needle design permits maximum flow capacity in the controlled direction. Metal to metal needle and ball seats insure long trouble-free service. Simple, practical "O" gland structure eliminates troublesome leaking. Valve bodies machined from hex brass or aluminum for 2000 psi working pressures; steel and stainless steel for 5000 psi. Made in 5 female pipe sizes—⅛" to ¾". ATTRACTIVE PRICES . . . IMMEDIATE DELIVERY.

Write for illustrated circular and prices.

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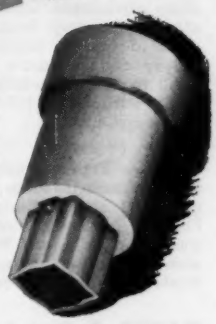
Circle 575 on page 19

High-Impact-Strength High Temperature

BRUSH HOLDERS



New PHOENIX "Pemester"

High performance Phoenix "Pemester" Brush Holders and Caps are for motors that get the really rugged duty... new "Pemester" material gives high-impact-strength, dimensional stability up to 400°F. and molds to close tolerances in any quantity . . . Available *only* from Phoenix in the complete "Customized-Standard" line of sizes and types—or to your specifications.

Write for full information contained in big, new, easy-to-use Phoenix Catalog 57-L. Your copy free on request.

PHOENIX ELECTRIC MANUFACTURING CO.

4211 West Lake Street Chicago 24, Illinois

Circle 576 on page 19

If GEARS Are YOUR Problem

We Can . . .

- act as your precision gear department
- keep your production line going smoothly without shut-downs
- reduce rejects, hand adjustments or other supervisory attention
- provide you with precise gearing for any purpose whatever
- and do it with a strict adherence to safe engineering economy

SPECIALISTS IN THE FINE PITCH FIELD

Use our more than a decade of experience in Gear making, in any material, for America's most particular users of precision or commercial gears. Send blueprints or specs for prompt estimates to

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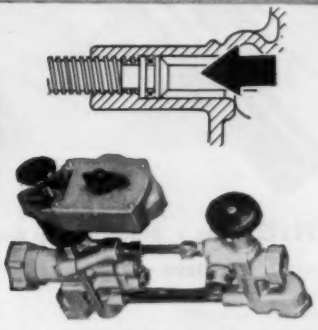
Circle 577 on page 19

problem: *find a low-friction seal that positively seals at extremely low pressures*

new answer: *minnesota rubber's money-saving new*

evidence:



THE LINDSAY COMPANY, world's largest manufacturer of automatic home water softeners, uses three QUAD RINGS in its newest valve. Lindsay tested O-rings in the valve, but O-rings leaked at very low pressures. Then Lindsay tested QUAD RINGS, a revolutionary new seal originated and manufactured by Minnesota Rubber. QUAD RINGS sealed perfectly no matter how low the pressure. The Lindsay Company also found that it could open some of the tolerances on the valve parts—and save money—because QUAD RINGS give such a good seal with low friction.

QUAD RINGS are injection molded. Denser, tougher. 4-lip action even seals at less than 1 psi! Only 60-100 micro-inch groove finish needed. No parting line on sealing surface. Eliminates "spiral twist".

free samples and data:

Free samples of QUAD RINGS are available with a descriptive brochure of technical information and installation data.

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Circle 578 on page 19

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AVAILABLE OR WANTED

WANTED: The University of Nevada at Reno, Nevada has openings on the teaching staff of the College of Engineering at the ranks of Instructor or Assistant Professor in Mechanical Engineering. Address Dean of Engineering for particulars.

WANTED: Design Engineer—Outstanding opportunity for professional advancement with well-established, expanding firm in Dallas, Texas. BS Degree required with minimum of three years' practical experience in mechanical design and development—preferably of light process or materials handling equipment. Company's products are used internationally in chemical, food, and agricultural processing. Experience in one or more of these industries will be helpful. Salary commensurate with experience and proven ability. Send resume including age, experience, and salary requirement to Box 911, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

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WANTED: Equipment Designer. Established expanding midwestern company looking for engineering graduate with experience in design of medium and heavy machinery. Qualified person would ultimately be in charge of newly formed department. Knowledge of stress analysis of static and dynamically loaded members necessary. Non-destructive testing experience desirable but not necessary. Customer contact work will require limited amount of travel. Address Box 916, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

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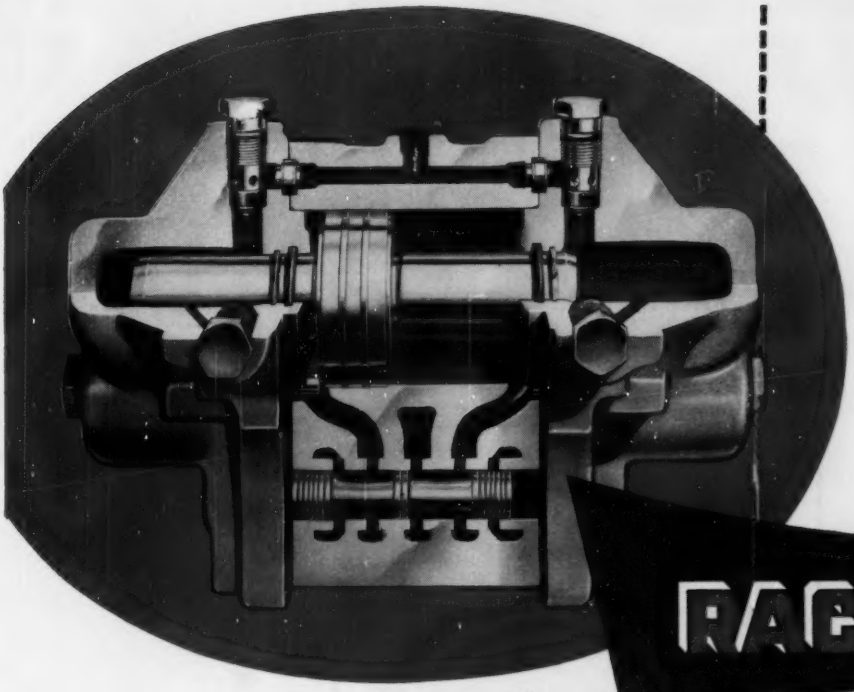

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HYDRAULIC PRESSURE BOOSTERS

HIGH PRESSURE VALUES— AT LOW PRESSURE COSTS

This patented RACINE PRESSURE BOOSTER builds pressures as high as 5000 psi. With it you can economically multiply the pressure from your low pressure pump as much as seven to one

It allows you to use low pressure at low cost for many operating and closing actions. High pressures to 5000 psi, automatically cut in for final forming and holding operations, or curing cycles on your machine.

Simple design, pressure lubricated, rugged parts and the use of extremely high tensile materials make RACINE Pressure Boosters practically indestructible They last for *years and years* with little maintenance or repair.

If you need pressures to 5000 psi, write us now. Learn how you can have "High Pressure Values at Low Pressure Costs."

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Variable Volume
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Hydraulic Pump

4-WAY VALVE
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50 to 3500 rpm
Pressures to 1500 psi

RESERVOIR
With Control Panel
Designed to your space
and circuit requirements

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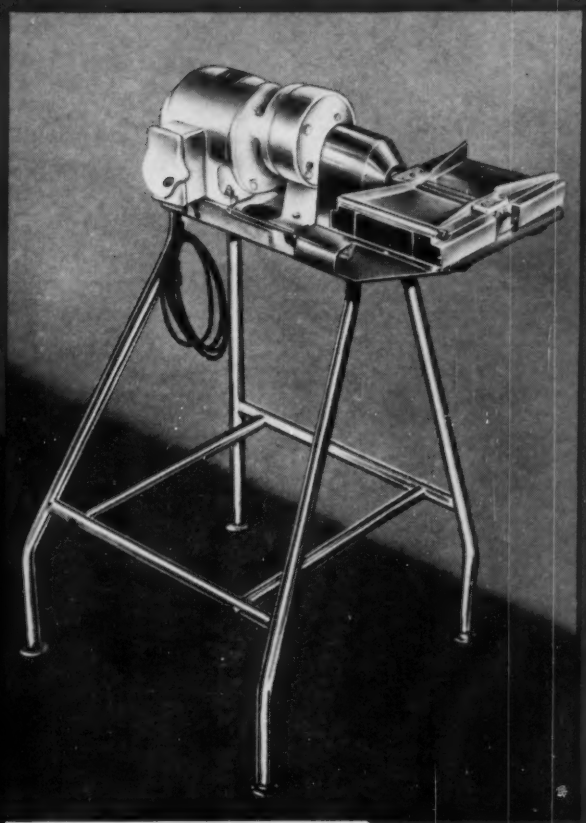


Power Gizzard Skinner Means Better Production for packers! Driven by a Master ¼ H.P. Double Parallel Gearmotor, output speed 230 R.P.M.

ANOTHER DRIVE REQUIREMENT MEETS ITS MASTER

"But my drive problems are different," you say, and right you undoubtedly are. Far as we know, this Master-powered Gizzard Skinner is unique.

But here's the point. America's productive genius consists of the ability to analyze a problem, devise a system and apply power to it in such a way as to produce better results faster at less cost. And *that problem* we bet you've got!

Let us help! Tell us the problem. From the drives listed here—or a combination of the required ones in one compact efficient unit—we'll deliver the goods! That's just what we've done for many, many years, to an ever-enlarging cross-section of American industry jealous of the performance of their motor equipment.

Motor Ratings..⅛ to 400 H.P. All phases, voltages and frequencies.

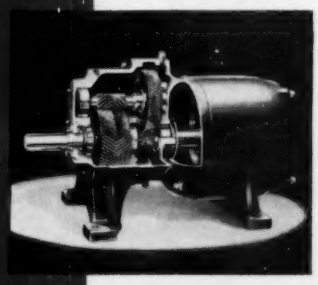
Motor Types.....Squirrel cage, slip ring, synchronous, repulsion-start induction, capacitor, direct current.

Construction....Open, enclosed, splash-proof, fan-cooled, explosion-proof, special purpose.

Speeds.....Single-speed, multi-speed, and variable speed.

Installation.....Horizontal and vertical, with or without flanges and other features.

Power Drive Features.....Electric brakes (2 types)—5 types of gear reduction up to 432 to 1 ratio. Mechanical and electronic variable speed units—fluid drives—every type of mounting.



THE MASTER ELECTRIC COMPANY

Dayton 1, Ohio

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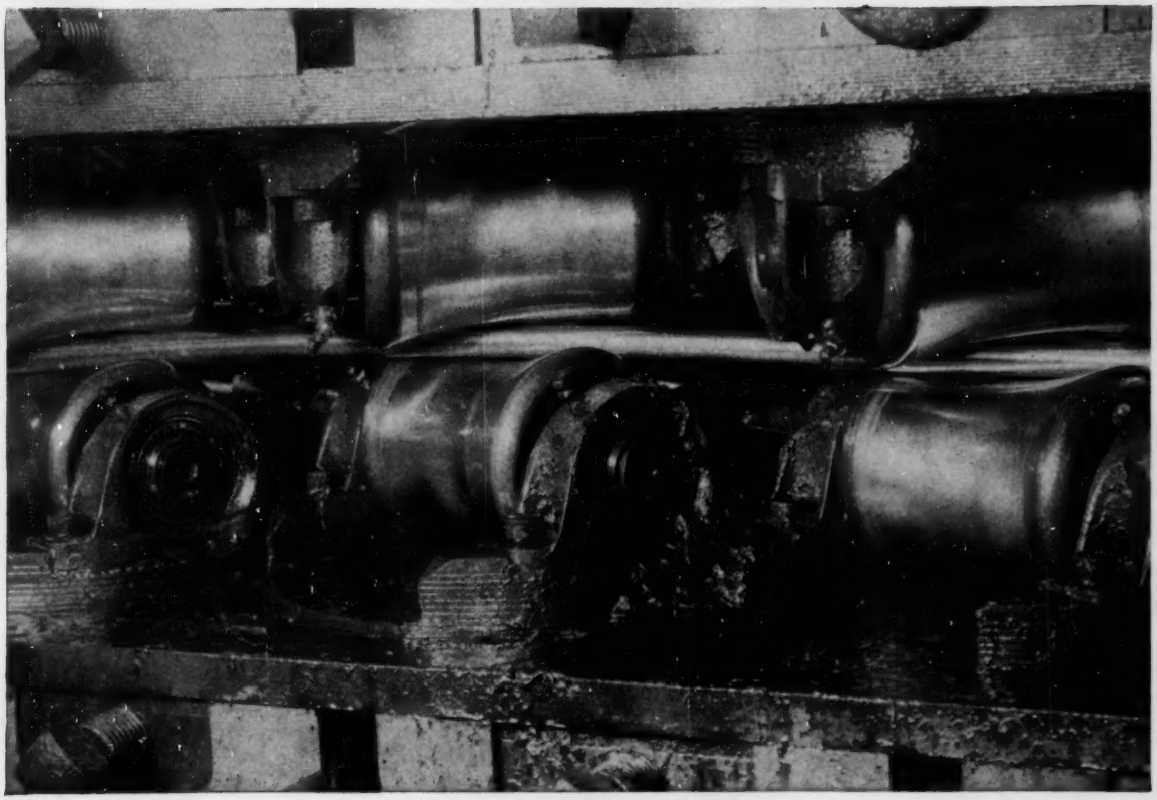

Uses tool steel that outwears others 3 to 1 for its straightener rolls

TO help its customers get the longest possible life out of the rolls used in its small tube straighteners, Mackintosh-Hemphill Division of E. W. Bliss Co. makes them from Graph-Mo® steel.

Graph-Mo contains millions of tiny particles of diamond-hard carbides. As a result, users report it outwears other tool steels on an average of three to one!

Graph-Mo steel also contains free graphite which gives it outstanding anti-friction properties, prevents pick up and scoring. This is a big advantage to users of small Mack-Hemp straighteners because it results in a better surface on the products being processed. What's more it eliminates chrome plating the rolls, which is usually necessary when the straighteners are used for non-ferrous metals such as brass.

Graph-Mo steel gives Mackintosh-Hemphill two other important manufacturing advantages. It saves machining time because it's 30% easier to machine than ordinary tool steels. And it simplifies heat treating because of its uniform response to heat treatment.

Graph-Mo is one of four graphitic tool steels developed by the Timken Company. If you want more information about their use in dies, punches, gages and machine parts, write for the new Timken Graphitic Steel Data Book. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U. S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

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